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Silvical Characteristics of Subalpine Fir

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Abstract

This report summarizes information on distribution, botanical description, habitat conditions, life history, special uses, and genetics of subalpine fir.

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Silvical Characteristics of Subalpine Fir

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Contents

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Subalpine fir, the smallest of eight species of true fir indigenous to the western United States, is distinguished by the long, narrowly conical crown terminating in a conspicuous spikelike point (fig. 1).

Two varieties are recognized: the typical variety (*Abies lasiocarpa* var. *lasiocarpa* (Hook.) Nutt.) and corkbark fir (*Abies lasiocarpa* var. *arizonica* (Merriam) Lemm.). The latter, readily distinguished by its peculiar whitish, corky bark, is restricted to the Rocky Mountains of southern Colorado, Arizona, and New Mexico. Other common names for the typical variety include balsam, white balsam, alpine fir, western balsam fir, balsam fir, Rocky Mountain fir, white fir, and pino real blanco de las sierras; for corkbark fir, alamo de la sierra (Little 1979).

Figure 1.—Mature subalpine fir on the Fraser Experimental Forest, Colorado.

Throughout much of the Rocky Mountains, subalpine fir has no special or unique properties. By providing cover, subalpine fir assists in protecting watersheds and rehabilitating the landscape. Forests in which subalpine fir grows occupy the highest water-yielding areas in much of the west. They also provide habitat for a variety of game and nongame animals, forage for livestock, recreational opportunities, and scenic beauty. However, these properties are indigenous to the sites where subalpine fir grows rather than to any special properties associated with the species.

DISTRIBUTION

Subalpine fir is widely distributed (fig. 2). It ranges from 32° N. latitude in Arizona and New Mexico to 64°30′ N. in Yukon Territory, Canada. Along the Pacific coast, the range extends from southeastern Alaska, south of the Copper River Valley (lat. 62° N.) the northwestern limit; east to central Yukon Territory (lat. 64°30′ N.) the northern limit, south through British Columbia along the east slopes of the Coast Range to the Olympic Mountains of Washington, and along both slopes of the Cascades to southern Oregon. It is not found on the west slopes of the Coast Range in southern British Columbia or along the Coast Range in Washington and Oregon, but it does occur on Vancouver Island (Alexander 1958, 1965, 1980). It is also found locally in northeastern Nevada and northwestern California (Little 1971). Except where noted above, subalpine fir is a major component of high elevation Pacific Northwest forests.

In the Rocky Mountain region, subalpine fir extends from the interior valleys of British Columbia west of the Continental Divide and south of the Peace River (lat. 55° N.), south along the high elevations of the Rocky Mountain system to southern New Mexico and Arizona. In the north, its range extends from the high mountains of central British Columbia, western Alberta, northeastern Washington and northeastern Oregon, Idaho, Montana, to northwestern and north-central Wyoming. In Utah, it commonly occurs in the Uinta and Wasatch Mountains but is less abundant on the southern plateaus. The range extends from southern Wyoming, through the high mountains of Colorado and northern New Mexico, and westward through northeastern Arizona to the San Francisco Mountains (Alexander 1958, 1965, 1980). Subalpine fir is also a major component of the high-elevation forests of the Rocky Mountains.

Corkbark fir is found mixed with subalpine fir on scattered mountains in southwestern Colorado; northern, western and southwestern New Mexico; and in the high mountains of Arizona (Little 1979).

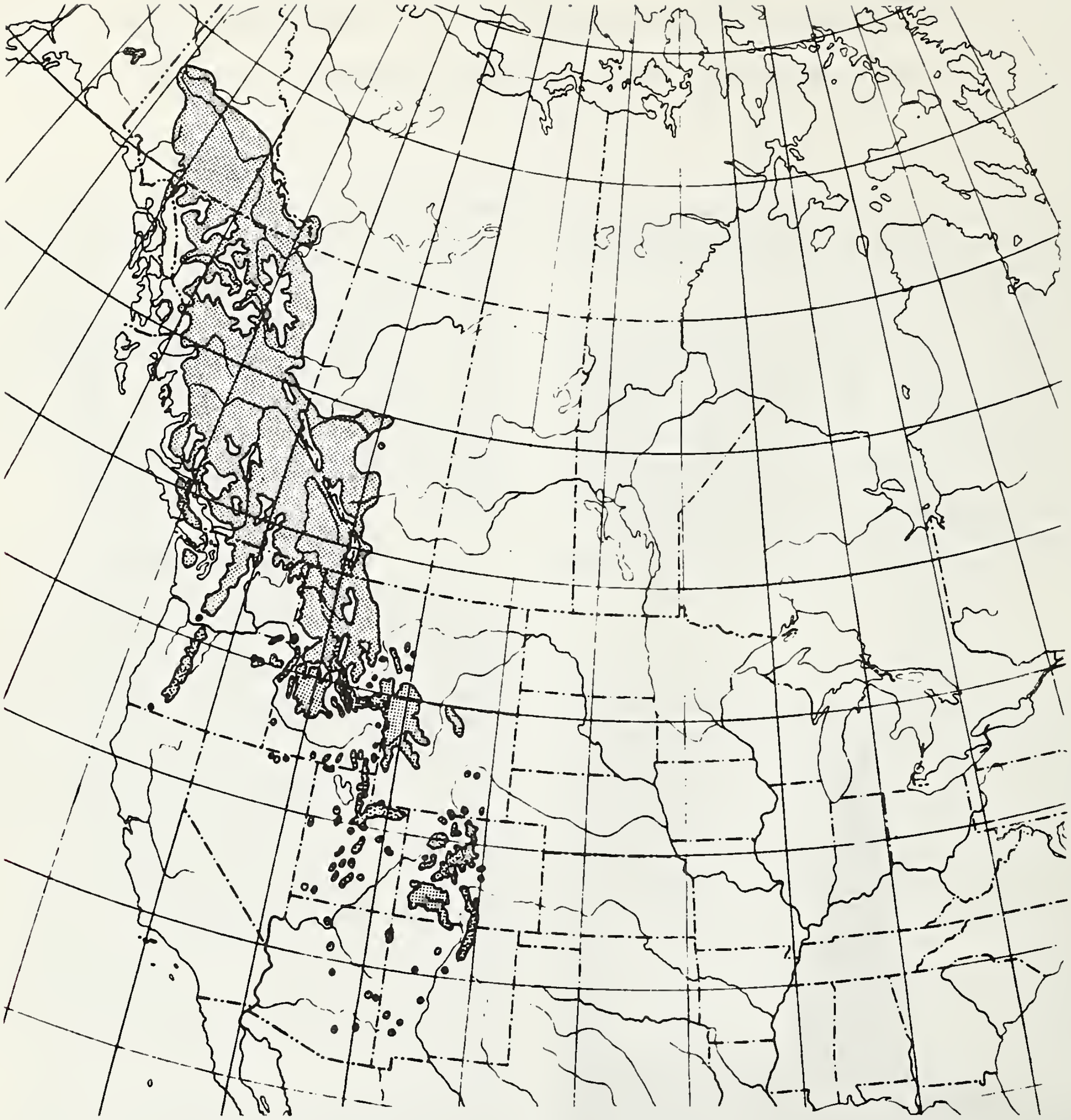

Figure 2.—Natural range of subalpine fir.

BOTANICAL DESCRIPTION

The botanical features of subalpine fir, as described by Preston (1948) and Liu (1971), are as follows:

Needles.—Needles are pale blue-green, crowded, nearly erect, and sessile. On the lower branches, they are about 1 to 1-3/4 inches long, and either flattened, blunt, or notched. On the upper branches, needles are about 1/2 inch long and pointed (fig. 3A).

Flowers.—Male flowers are usually dark indigo-blue and are borne on the lower branches (fig. 3A), while the violet-purple female flowers are borne on the upper branches.

Cones.—The cones are usually 2-1/2 to 4 inches long, ovate to cylindrical, and characteristically purplish gray to nearly black when ripe (fig. 3B). Cone scales are longer than broad and about three times longer than the long-tipped bracts.

Seeds.—Seeds average about 1/4 inch long and have dark lustrous wings (fig. 3B).

Twigs.—The stout, pubescent twigs are pale orange, becoming smooth and gray or silver white with age.

Winter buds.—These are subglobose, resinous, and about 1/8 to 1/4 inch long, with light orange-brown scales.

Bark.—The bark is thin, gray, and smooth except for numerous resin blisters on young trees. It becomes shallowly fissured, especially near the base, with age (fig. 3C).

Wood.—Both the heartwood and sapwood, which are generally difficult to distinguish, are creamy white to pale brown, soft, stiff, fine-textured, straight-grained, and nonresinous.

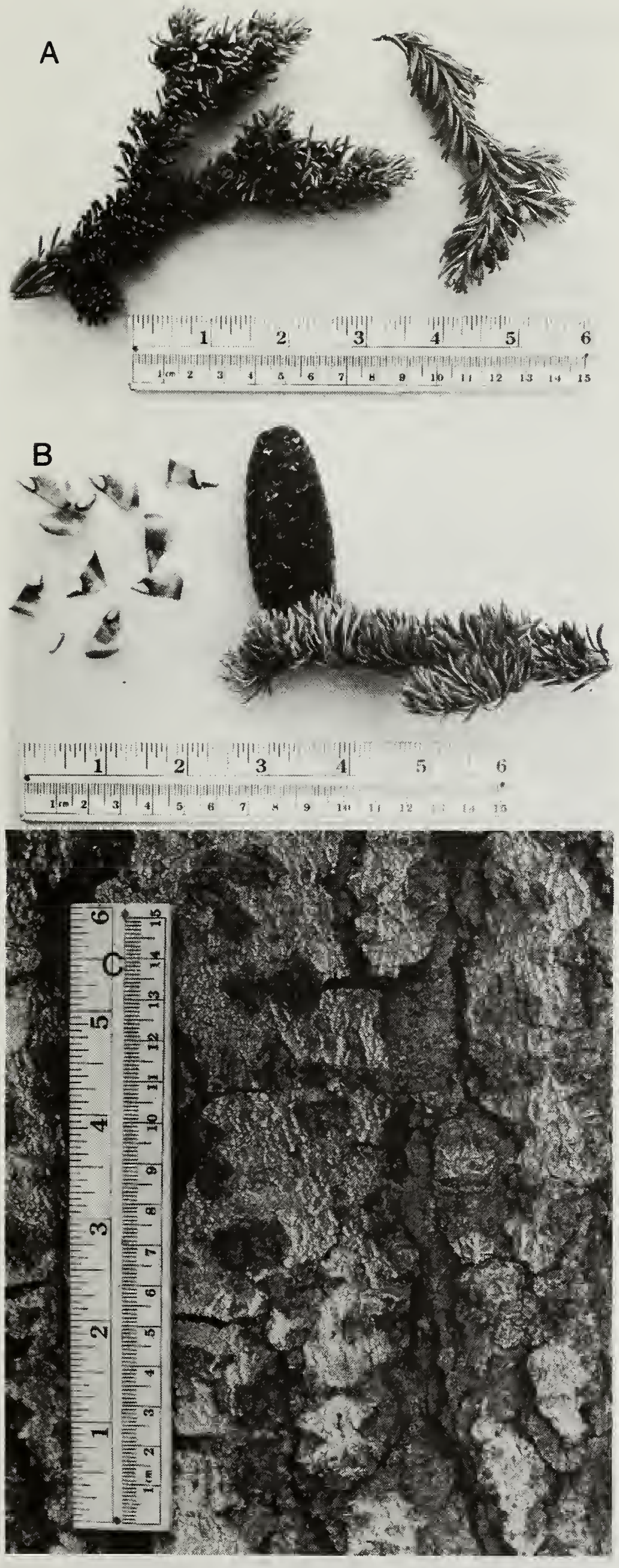

Figure 3.—Botanical features of subalpine fir: A, needles and male flowers; B, mature cones and seeds; C, bark.

HABITAT CONDITIONS

Climate

Subalpine fir grows in the coolest and wettest forested continental area of the western United States (Thornwaite 1948). Temperatures range from below −50° F in the winter to more than 90° F in the summer. Although widely distributed, subalpine fir grows within a narrow range of mean temperatures. Mean annual temperatures vary from 25° F to 40° F, with a July mean of 45° F to 60° F, and a January mean of 5° F to 25° F (Baker 1944, Haefner 1971, Marr et al. 1968) (table 1).

Average precipitation is in excess of 24 inches, much of which falls as snow. More than half of the precipitation occurs from late fall to late winter in the Pacific Northwest and west of the Continental Divide in the Rocky Mountains north of Utah and Wyoming. East of the divide in the Rocky Mountains north of New Mexico and Arizona, the heaviest precipitation comes in late winter and early spring. In the Rocky Mountains and associated ranges in Arizona and New Mexico, most precipitation comes during late summer and early fall (Baker 1944, Thornwaite 1948). However, cool summers, cold winters, and development of deep winter snowpacks are more important than total precipitation in differentiating where subalpine fir grows in relation to other species.

Soils

Information on soils where subalpine fir grows is limited. In the Pacific Coast region, soil parent materials are mixed and varied. Zonal soils in the subalpine fir zone are Cryorthods (Podzolic soils), or Haplorthods (Brown Podzolic soils) with well-developed but ultimately thin humus layers. Haploxeruts and Haplahumults (Reddish-Brown Lateritic soils) developed from volcanic lava, Xerochrepts (Regosolic soils) developed from shallow residual material, and Lithic (Lithosolic soils) are also common in some localities. Dystrandepts (Bog soils) and Haplaquepts (Humic Gley soils) occur on poorly drained situations. Soils are more acid than in lower elevation forests, with pH typically ranging from 4.5 to 5.9 (Franklin and Dyrness 1973, USDA SCS 1975).

In the Rocky Mountain subalpine zone, soil materials vary according to the character of the bedrock from which they originated. Crystalline granitic rock predominates, but conglomerates, shales, sandstones, basalts, and andesites commonly occur. Glacial deposits and stream alluvial fans are also common along valley bottoms of the great soils groups; Cryorthods (Podzolic soils) and Haplorthods (Brown Podzolic soils) occur extensively on all aspects. Aquods (Ground-water Podzolic soils) are found in the more poorly drained areas. Eutroboralfs (Grey-Wooded soils) are found where timber stands are less dense and parent material finer textured. Eutrochrepts (Brown Forest soils) occur mostly along stream terrains and sideslopes in the lower subalpine; Lithic (Lithosolic soils) occur whenever bedrock is near the surface. Dystrandepts (Bog soils)

Table 1.—Climatological data for four regional subdivisions within the range of subalpine fir

Location	Average temperature Annual	July	January	Annual precipitation	Annual snowfall	Frostfree period
	--------°F	--------	--------	------------ inches	------------	days
Pacific Northwest	30–40	45–55	15–25	24–100 +	600 +	30–60
Rocky Mountain						
Northern[1]	25–35	45–55	5–15	24–60	250 +	[4]30–60
Central[2]	30–35	50–55	10–15	24–55	150–350 +	[4]30–60
Southern[3]	30–40	50–60	15–20	24–40 +	200 +	[4]30–75

[1]*Includes Rocky Mountains north of Wyoming and Utah and associated ranges in eastern Washington and Oregon.*
[2]*Includes Rocky Mountains of Colorado, Wyoming and Utah.*
[3]*Includes Rocky Mountains and associated ranges of New Mexico and Arizona and plateaus of southern Utah.*
[4]*Least can occur any month of the year.*

and Haplaquepts (Humic Gley soils) occur extensively in poorly drained upper stream valleys (Johnson and Cline 1965, USDA SCS 1975).

Regardless of the great soils groups that occur in the subalpine zone of the west, subalpine fir is not exacting in its soil requirements. It is frequently found growing on soils that are too wet or too dry for its common associates. Good growth is made on lower slopes, alluvial floodplains, and glacial moraines; and at higher elevations on well-drained fine- to medium-textured sand and silt loams, developed primarily from basalt, andesite, and shale. Growth is poor on shallow and coarse-textured soils developed from granitic and schistic rock, conglomerates, and coarse sandstones, and on saturated soils, but subalpine fir establishes on severe sites such as lava beds, tallus slopes, and avalanche tracks before any of its common associates. Under these conditions it may pioneer the site for other species or it may exclude the establishment of other species (Alexander 1958, 1965; Franklin and Mitchell 1967).

Topography

Subalpine fir grows near sea level at the northern limit of its range, and as high as 12,000 feet in the south. In the Coast Range of southeastern Alaska, it is found from sea level to 3,500 feet; in the Coast Range and interior plateaus of Yukon Territory and British Columbia, at 2,000 to 5,000 feet; and in the Olympic and Cascade Mountains of Washington and Oregon, generally at 4,000 to 6,000 feet, but as low as 2,000 feet along cold streambottoms and on lava flows and as high as 8,000 feet on sheltered slopes (Alexander 1980, Sudworth 1916).

In the Rocky Mountains of British Columbia and Alberta south of the Peace River, subalpine fir grows at 3,000 to 7,000 feet, but it is more abundant above 5,000 feet; in the Rocky Mountains of Montana and Idaho and associated ranges in eastern Washington and Oregon, at 2,000 to 11,000 feet, but it is more common at 5,000 to 9,000 feet (Kirkwood 1922, Larson 1930); in the Rocky Mountains of Wyoming, Utah, and Colorado, usually at 9,000 to 11,000 feet, but it may be found as low as 8,000 feet and to timberline at 11,500 feet; and in the Rocky Mountains and associated ranges of New Mexico and Arizona at 8,000 to 12,000 feet, but usually on north slopes at 9,500 to 11,000 feet (Bates 1924, Marr 1961, Pearson 1931).

Associated Vegetation

Trees

In the Rocky Mountains, subalpine fir is most typically found in mixture with Engelmann spruce (*Picea engelmannii* Parry ex Engelm.) and forms the relatively stable Engelmann spruce—subalpine fir type (SAF Type 206) (Society of American Foresters 1980). It is also found in varying degrees in 16 other cover types:

SAF Type Number	Type
201	White Spruce
202	White Spruce—Paper Birch
205	Mountain Hemlock
208	Whitebark Pine
209	Bristlecone Pine
210	Interior Douglas-fir
212	Western Larch
213	Grand Fir
215	Western White Pine
216	Blue Spruce
217	Aspen
218	Lodgepole Pine
219	Limber Pine
223	Sitka Spruce
224	Western Hemlock
226	Coastal True Fir—Hemlock

Differences in elevation and latitude affects temperatures, and precipitation thereby influencing the composition of the forests where subalpine fir grows

(Daubenmire 1943).[3] In Alaska and the Coast Range of British Columbia south through the Coast Range of Washington and Oregon, mountain hemlock (*Tsuga mertensiana* (Bong.) Carr) is its common associate. In Alaska and northern British Columbia, Alaska-cedar (*Chamaecyparis nootkatensis* (D. Don) Spach) mixes with it, and where it approaches sea level, it mingles with Sitka spruce (*Picea sitchensis* (Bong.) Carr). From southern British Columbia southward through much of the Cascades, Pacific silver fir (*Abies amabilis* Dougl. ex Forbes), mountain hemlock, and lodgepole pine (*Pinus contorta* Dougl. ex Loud.) are the most common associates under closed forest conditions. Major timberline associates are mountain hemlock and whitebark pine (*Pinus albicaulis* Engelm.). Engelmann spruce is not a constant associate of subalpine fir except on the east slopes of the northern Cascades, and on exceptionally moist, cool habitats scattered throughout the southern and western Cascades. Engelmann spruce is a major associate of subalpine fir in the mountains of eastern Washington and Oregon. Less common associates in the Pacific Northwest include western hemlock [*Tsuga heterophylla* (Raf.) Sarg.], noble fir (*Abies procera* Rehd.), grand fir (*Abies grandis* (Dougl. ex D. Don) Lindl.), western white pine (*Pinus monticola* Dougl. ex D. Don), western larch (*Larix occidentalis* Nutt.), and subalpine larch (*Larix lyallii* Parl.) (Alexander 1958, 1965, 1980).

From the mountains and interior plateaus of central British Columbia southward through the Rocky Mountain system, its most constant associate is Engelmann spruce. Less common associates include: in British Columbia and western Alberta, white spruce (*Picea glauca* (Moench) Voss), balsam poplar (*Populus balsamifera* L.), paper birch (*Betula papyrifera* Marsh.), quaking aspen (*Populus tremuloides* Michx.); in the Rocky Mountains of Montana and Idaho at its lower limits, western white pine, Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco), western hemlock, western larch, grand fir, and western redcedar (*Thuja plicata* Donn ex D. Don); and at higher elevations, lodgepole pine, subalpine larch, mountain hemlock, and whitebark pine. In the Rocky Mountains of Wyoming, Utah, and Colorado, near its lower limits, associates are lodgepole pine, Douglas-fir, aspen, and blue spruce (*Picea pungens* Engelm.); and at higher elevations, whitebark pine, limber pine (*Pinus flexilis* James), and bristlecone pine (*Pinus aristata* Engelm.); and in the Rocky Mountains and associated ranges of New Mexico and Arizona, near its lower limits, white fir (*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.), Rocky Mountain Douglas-fir, blue spruce, and aspen; and at higher elevations, corkbark fir. Subalpine fir frequently extends to timberline in the Rocky Mountains. Other species that accompany it to timberline are whitebark pine, mountain hemlock, and occasionally Engelmann spruce in the Rocky Mountains north of Utah and Wyoming; Engelmann spruce in the Rocky Mountains of Wyoming, Utah, and Colorado; and Engelmann spruce and corkbark fir in the Rocky Mountains and associated ranges south of Wyoming and Utah (Alexander 1958, 1965, 1980).

At timberline in the Rocky Mountains, subalpine fir and Engelmann spruce form a wind krummholz 3 to 7 feet high. On gentle slopes below timberline, subalpine fir, Engelmann spruce, and occasionally lodgepole pine grow in north-south strips 33 to 164 feet wide and several hundred yards long approximately at right angles to the direction of prevailing winds. These strips are separated by moist subalpine meadows 82 to 246 feet wide where deep snowdrifts accumulate (Billings 1969).

Understory

Understory vegetation is more variable than tree associates. In the Pacific Northwest and the Rocky Mountains and associated ranges north of Utah and Wyoming, common undergrowth species include the following: Labrador tea (*Ledum glandulosum* Nutt.), Cascades azalea (*Rhododendron albiflorum* Hook.), rusty skunkbush (*Menziesia ferruginea* Smith), woodrush (*Luzula hitchcockii* Hamet-Ahtl), Rocky Mountain maple (*Acer glabrum* Torr.), twinflower (*Linnaea borealis* L.), and heartleaf arnica (*Arnica cordifolia* Hook.) on cool, moist sites; queenscup beadlily (*Clintonia uniflora* (Schult.) Kunth), twistedstalk (*Streptopus amplexifolius* (L.) DC.), and sweetscented bedstraw (*Galium triflorum* Michx.) on warm, moist sites; dwarf blueberry (*Vaccinium caespitosum* Michx.), grouse whortleberry (*V. scoparium* Leiberg), fireweed (*Epilobium angustifolium* L.), mountain gooseberry (*Ribes montigenum* McClat.), and blue huckleberry (*V. globulare* Rydb.) on cool, dry sites; beargrass (*Xerophyllum tenax* (Pursh.) Nutt.), myrtle boxleaf (*Pachistima myrsinites* (Pursh.) Raf.), elksedge (*Carex geyeri* Boott), common juniper (*Juniperus communis* L.), white spirea (*Spiraea betulifolia* Hook.), pinegrass (*Calamagrostis rubescens* Buckl.), and big whortleberry (*V. membranaceum* (Hook.) C. L. Hitchc.) on warm, dry sites; and marshmarigold (*Caltha leptosepala* DC.), devilsclub (*Oplopanax horridum* (J. E. Smith) Miq.), and bluejoint reedgrass (*Calamagrostis canadensis* (Michx.) Beauv.) on wet sites (Daubenmire and Daubenmire 1968; Franklin and Dyrness 1973; Pfister 1972; Pfister et al. 1977; Steele et al. 1981, 1983).

Undergrowth characteristically found in the Rocky Mountains and associated ranges south of Idaho and Montana include the following: mountain bluebells (*Mertensia ciliata* (James) D. Don) and heartleaf bittercress (*Cardimine cordifolia* Gray) on cool, moist sites; russet buffaloberry (*Shepherdia canadensis* (L.) Nutt.), Oregon grape (*Berberis repens* Lindl.), myrtle boxleaf, elksedge, common juniper, mountain snowberry (*Symphoricarpos oreophilus* Gray), daisy fleabane (*Erigeron superbus* Rydb.), heartleaf arnica, and Arizona peavine (*Lathyrus arizonicus* Britt.) on warm, dry sites; and Rocky Mountain whortleberry (*V. myrtillus* L.), grouse

[3] *Classification of forest vegetation into "habitat types" based on methodology developed by Daubenmire (1952) and modified by others is available for much of the western forested lands. The known habitat types for all lands where subalpine fir grows are listed in the appendix with other descriptive material.*

whortleberry, fireweed, groundsel (*Senecio sanguisorboides* Rydb.), polemonium (*Polemonium pulcherrimum* Hook), prickly currant (*Ribes lacustre* (Pers.) Poir.), sidebells pyrola (*Pyrola secunda* L.), and mosses on cool, dry sites (Hess 1981; Hoffman and Alexander 1976, 1980, 1983; Moir and Ludwig 1979; Wirsing and Alexander 1975).

LIFE HISTORY

Reproduction and Early Growth

Flowering and Fruiting

Subalpine fir is monoecious. Male flowers (strobili), usually abundant, are borne in pendulous clusters from the axils of the needles on the sides of lower branchlets. Female flowers (strobili) are fewer and are borne erect and singly or in small groups on the uppermost branchlets of the crown. Male flowers ripen and pollen is wind-disseminated during the late spring and early summer. Cones open in mid-August to mid-October. Seed ripens from mid-September to late-October (Liu 1971, USDA Forest Service 1974).

Seed Production

Subalpine fir may begin to produce cones when they are 4 to 5 feet tall and 20 years old, but under closed-forest conditions, seed production is not significant until trees are older and taller. Corkbark fir does not begin to bear cones until about 50 years old. Maximum seed production for subalpine and corkbark fir occurs in dominant trees that are between 150 and 200 years old (USDA Forest Service 1974).

Subalpine fir is rated a good seed producer in the Pacific Northwest and in the Rocky Mountains of Idaho and Montana, with good to heavy crops borne every 3 years, and light crops or failures in between (Franklin et al. 1974, LeBaron and Jemison 1952). It is as good a seed producer as most associated true firs, but not as good as the hemlocks and Engelmann spruce. In one study covering an 11-year period at four locations in the Cascades, subalpine fir cone crops, based on the following criteria, were rated medium to very heavy in 6 years and very light to failure in the other 5 (Franklin et al. 1974).

Number of cones per tree	Crop rating
0	Failure
1–9	Very light
10–19	Light
20–49	Medium
50–99	Heavy
100+	Very heavy

In the Rocky Mountains south of Idaho and Montana, seed production of subalpine and corkbark fir has generally been considered to be poor, with more failures than good seed years. In one study in Colorado covering 42 area-seed crop years, subalpine fir was an infrequent seed producer. Some seed was produced in only 8 of the years, while the other 34 were complete failures (Noble and Ronco 1978). Similar results have been obtained from other seed production studies in Colorado. However, since these studies were designed to sample seed production in spruce-fir stands and since Engelmann spruce made up 90% or more of the dominant stand basal area, these results are only indicative of subalpine fir seed production in spruce-fir stands, not of individual dominant fir trees.

A number of cone and seed insects of subalpine fir have been identified but their relative importance, frequency of occurrence, and the magnitude of losses are not known (Hedlin et al. 1980, Keen 1958). Some seed is lost from cutting and storing of cones by pine squirrels (*Tamiasciurus hudsonicus fremonti* Audubon and Bachman), and after seed is shed small mammals such as deer mice (*Peromyscus maniculatus* Wagner), red-backed mice (*Clethrionomys gapperi* Vigors), mountain voles (*Microtus montanus* Peale), and western chipmunks (*Eutamias minimus* Bachman) consume a portion of the seeds (Alexander 1974). However, the quantitative losses from mammals, birds, and other causes are not known.

Seed Dissemination

Cones disintegrate when they are ripe. Scales with bracts fall away with the large, winged seeds, leaving only a central spikelike axis. Dissemination begins in September and usually is completed by the end of October in the Rocky Mountains (USDA Forest Service 1974). In the Pacific Northwest, seed dissemination begins in October and usually continues into November, but pitched-up cones may extend dissemination into December. Practically all seed is dispersed by the wind.[4]

Subalpine fir seeds are fairly large, averaging 34,800 per pound. Corkbark fir seeds are larger, averaging about 22,300 per pound. There are few data available on the seed dispersal distances. Studies designed to measure Engelmann spruce seed dispersal show similar dispersal patterns for subalpine fir. Prevailing winds influence the dispersal pattern at high elevations with about one-half of the seeds falling into openings within 100 feet of the windward timber edge. Seedfall continues to diminish until about two-thirds of the way across the opening and then levels off before slightly increasing about 50 feet from the leeward timber edge (Noble and Ronco 1978). Thermal upslope winds are important in seed dispersal in mountainous terrain at mid to lower elevations (Shearer 1980).

Seed Viability and Germinative Capacity

Subalpine fir seed viability is only fair; average germinative capacity is 34% and vitality transient (USDA Forest Service 1974). However, observations and limited

[4] *Personal communication with Dr. J. F. Franklin, Chief Plant Ecologist, Pacific Northwest Forest and Range Experiment Station, Corvallis, Oreg.*

studies in the Rocky Mountains indicate that germinative capacity is often less than 30% (Shearer and Tackle 1960). Some lots of stored seeds exhibit embryo dormancy, which can be broken by stratification in moist sand or peat at 41° F for 60 days (USDA Forest Service 1974).

Seedling Establishment and Survival

Under natural conditions, fir seeds lie dormant under the snow and germinate the following spring. Although germination and early survival of subalpine fir is generally best on exposed mineral soil and moist humus, it is less exacting in its seedbed requirements than most of its common associates. Subalpine fir has been observed to germinate and survive on a wide variety of other seedbed types including the undisturbed forest floor, undecomposed duff and litter, and decaying wood (Alexander 1958, 1965; Clark 1969; Day 1964). Subalpine fir also invades and establishes on severe sites such as recent burns, lava flows, tallus slopes, avalanche tracks, and climatically severe regions near timberline (Franklin and Mitchell 1967). Success of subalpine fir on these open sites results from its ability to establish a root system under conditions too severe for its less hardy associates, and its ability to reproduce by layering.

Although subalpine fir grows under nearly all light intensities found in nature, establishment and early survival are usually favored by shade. In the absence of Pacific silver fir, grand fir, and mountain hemlock, subalpine fir will survive under closed forest conditions with less light than Engelmann spruce, noble fir, and white spruce (Franklin and Mitchell 1967). When grown with Pacific silver and grand fir, and/or mountain hemlock, subalpine fir does not compete successfully under closed forest conditions. It cannot compete successfully with the spruces, lodgepole pine, or Rocky Mountain Douglas-fir when light intensity exceeds 50% of full shade (Alexander 1958, 1965).

Subalpine fir is restricted to cold, humid habitats because of low tolerance to high temperatures. Newly germinated subalpine fir seedlings tolerate high solar radiation but they are susceptible to heat girdling and drought. Seedlings are also killed or damaged by spring frosts, competing vegetation, frost heaving, damping off, snowmold, birds, rodents, and trampling and browsing by large animals, but losses are no different than for any common associate (Alexander 1974).

The number of seeds required to produce a first-year seedling, and an established seedling (at least 3 years old), and the number of first-year seedlings that produce an established seedling vary considerably, depending upon seed production, distance from source, seedbed, and other environmental conditions. In one study in Colorado, covering the period 1961 to 1975 and a wide variety of conditions, an average of 150 seeds (range 35-290) was required to produce a first-year seedling, and an average of 755 seeds (range 483-1,016) to produce an established seedling. For every established seedling, it required an average of 10 first-year seedlings, with a range of as few as 4 to as many as 14 (Noble and Ronco 1978).

Early Growth

Early growth of subalpine fir is very slow. The root length of first-year seedlings in one study in British Columbia averaged only 2.7 inches (Eis 1965). No comparable data are available in the United States, but first-year penetration of corkbark fir in Arizona averaged 3.4 inches (Jones 1971).

Shoot growth is equally slow at high elevations. First-year seedlings are frequently less than 1 inch tall. Mean annual height growth of seedlings during the first 10-20 years is usually not much better (fig. 4). In one study, seedlings 15 years old averaged only 11 inches in height on burned-over slopes, 10 inches on cutover, dry slopes, and 6 inches on cutover, wet flats (Hodson and Foster 1910). In another study, seedlings grown on mineral soil averaged only 24 inches in height after 21 years (Herring and McMinn 1980). In general, trees reach 4 to 5 feet in height in about 20 to 40 years under favorable environmental and stand conditions. However, trees less than 5 inches in diameter are often 100 or more years old at higher elevations, and trees 4 to 6 feet high and 35 to 50 years old are common under closed-forest conditions (fig. 5) (Kirkwood 1922, Oosting and Reed 1952).

At lower elevations, seedling shoot growth is somewhat better. In one study in the intermountain west, average annual height growth of subalpine-fir seedlings for the first 10-years after release was 4.5 inches on clearcuts and 3.2 inches on partial cuts (McCaughey and Schmidt 1982).

Vegetative Reproduction

Subalpine fir frequently reproduces by layering where the species is a pioneer in developing forest cover on severe sites such as lava flows and tallus slopes or near timberline (Franklin and Mitchell 1967). Under closed forest conditions, reproduction by layering is of minor importance.

Sapling and Pole Stage to Maturity

Growth and Yield

Natural Stands.—On exposed sites near timberline, subalpine fir is often reduced to a prostrate shrub, but under closed forest conditions, it attains diameters of 12 to 24 inches and heights of 45 to 100 feet, depending upon site quality and stand density (fig. 6). Trees larger than 30 inches in diameter and 130 feet tall are exceptional (Harlow and Harrar 1937, Sudworth 1916).

Growth is not rapid; trees 10 to 20 inches in diameter are often 150 to 200 years old under closed forest conditions. Trees older than 250 years are not uncommon. But because the species suffers severely from heartrot, many trees either die or are complete culls at an early age.

Few data are available on the yields of subalpine fir in natural stands. It usually grows in mixed stands and comprises only a minor part of the volume. In the Rocky Mountains and Pacific Northwest where it grows in association with Engelmann spruce, subalpine fir usually makes up only 10-20% of the sawlog volumes, which may vary from less than 5,000 to 40,000 fbm or more per acre (Hodson and Foster 1910, Miller and Choate 1964).

In the Pacific Northwest and Rocky Mountains, where subalpine fir grows with other true firs and/or mountain hemlock, few trees reach minimum merchantable size before being crowded out of the stand (Franklin and Mitchell 1967). Subalpine fir in the Rocky Mountains grows in pure stands most often on sites so severe that it has little commercial value. In the Pacific Northwest, pure stands on commercial sites typically occur on south slopes and are usually less than 150 years old. These stands are not extensive but are quite distinctive.[4]

Managed Stands.—The only data available for yields of subalpine fir in managed stands are estimates from simulations for mixed Engelmann spruce—subalpine fir stands in the Rocky Mountains south of Idaho and Montana (Alexander and Edminster 1980, Edminster 1978).

Figure 4.—Subalpine fir seedlings average less than 15 inches tall after 15 years in the open.

Figure 5.—Subalpine fir advanced reproduction released by removal of the overstory. Trees average 3 to 6 feet tall and area at least 50 years old.

Figure 6.—Dominant subalpine firs on the Fraser Experimental Forest, Colorado. These trees are about 12 to 14 inches in diameter, about 60 feet tall, and over 200 years old at d.b.h.

These simulations show that periodic thinning to control stand density and maintain growth rates increases the yield and size of individual fir trees in these mixed stands. Furthermore, the growth rates for fir are comparable to those for spruce. However, the fir component will be substantially reduced over time by repeat thinnings, so that the stand at the time of final harvest will be almost pure Engelmann spruce.

Rooting Habit

Subalpine fir has a shallow root system where it grows in situations that limit the depth of root penetration, and the superficial lateral root system common to the seedling stage persists to old age. Under more favorable conditions, subalpine fir develops a relatively deep lateral root system.

Reaction to Competition

In the Rocky Mountains and Pacific Northwest where subalpine fir and Engelmann spruce form the spruce-fir type, and mountain hemlock and other true firs are ab-

sent or limited in number, subalpine fir is very shade-tolerant (Franklin and Mitchell 1967). It is considerably more tolerant than spruce and other common associates such as lodgepole pine, quaking aspen, blue spruce, and Rocky Mountain Douglas-fir (Baker 1949). In most of the Cascades and in the Rocky Mountains where subalpine fir grows with the more shade-tolerant Pacific silver fir, grand fir, and mountain hemlock, some ecologists classify it as intolerant relative to these associates (Franklin and Mitchell 1967).

Subalpine fir together with Engelmann spruce forms a climax or long-lived seral forest vegetation throughout much of its range. In the Rocky Mountains of British Columbia and Alberta, and south of Montana and Idaho, subalpine fir and Engelmann spruce occur as either codominants or in pure stands of one or the other. Spruce, however, is most likely to form pure stands, especially at upper elevations. In the Rocky Mountains of Montana and Idaho, and the mountains of eastern Oregon and Washington, subalpine fir is a major climax. Engelmann spruce may be either a major climax or a persistent long-lived seral. Pure stands of either species may occur, but subalpine fir is most likely to form pure stands, especially at higher elevations (Alexander 1980).

Although subalpine fir is a dominant element in a number of climax or near-climax vegetation associations, these forests differ from most climax forests in that most stands are not truly all-aged. For example, in spruce-fir forests, some stands are single-storied while others are two-, three-, and multi-storied. Multi-storied stands may result from past disturbances such as fire, insect epidemics, or cutting, or they may result from the gradual deterioration of single- and two-storied stands associated with normal mortality from wind, insects, and diseases (Alexander 1974). On the other hand, some multi-storied stands appear to have originated as uneven-aged stands and are successfully perpetuating that structure (Hanley et al. 1975).

Where subalpine fir is a component of the climax vegetation, the natural tendency is for subalpine fir to reestablish itself when destroyed and temporarily replaced by other vegetation. Throughout most of the Cascades and in the Rocky Mountains where subalpine fir grows with the other true firs and/or mountain hemlock, it is seral (Franklin and Mitchell 1967).

The ecophysiology of subalpine fir in relation to common associated species is becoming better understood. Kaufmann (1982a, 1982b, 1984a, 1984b), Kaufmann and Troendle (1981), and Kaufmann et al. (1982), summarized what is known about the general water relations of subalpine fir as follows: (1) needle water vapor conductance (directly proportional to stomatal opening) is controlled primarily by visible irradiance and absolute humidity difference from needle to air (evaporative demand) with secondary effects from temperature and water stress; (2) nighttime minimum temperatures below 39° F retard stomatal opening the next day; (3) stomata function well from early spring to late fall, and high transpiration rates occur even with considerable snowpack on the ground; (4) leaf water vapor conductance is lower than that of Engelmann spruce, lodgepole pine, and aspen, the common associates of central Rocky Mountain subalpine forests; (5) subalpine fir trees have a larger total needle area per unit of sapwood water-conducting tissue than the other three species; and (6) subalpine fir trees have a slightly lower needle area per unit of bole or stand basal area than Engelmann spruce, but greater than lodgepole pine or aspen. At equal basal area, annual canopy transpiration of subalpine fir is about 35% lower than spruce, but 15% higher than lodgepole pine, and 110% higher than aspen. These high rates of transpiration cause subalpine fir to occur primarily on the wetter sites, generally in association with Engelmann spruce.

Silvicultural Systems and Cutting Methods

Both even- and uneven-aged silvicultural systems can be used in stands where subalpine fir is a component (Alexander 1974, 1977; Alexander and Engelby 1983; Shearer 1980). The appropriate even-aged cutting methods are clearcutting and shelterwood cutting and their modifications. The seed-tree method cannot be used because of the susceptibility of subalpine fir to windthrow. The uneven-aged cutting methods are individual-tree and group selection and their modifications. In spruce-fir stands, shelterwood and individual-tree selection methods will favor subalpine fir over Engelmann spruce, lodgepole pine, and Douglas-fir. In stands where subalpine fir grows with Pacific silver fir, grand fir, and/or mountain hemlock, clearcutting and group selection cutting will favor subalpine fir (Franklin and Mitchell 1967).

Damaging Agents

Windfall.—Subalpine fir is susceptible to windthrow. While this tendency is generally attributed to a shallow root system, root rots, soil depth, drainage, and stand conditions influence the development of the root system. The kind and intensity of cutting and topographic exposure to wind also influence the likelihood of trees being windthrown (Alexander 1974).

Insects.—Subalpine fir is attacked by several insects. In spruce-fir forests, the most destructive insect pests are the western spruce budworm (*Choristoneura occidentalis* Freeman) and western balsam bark beetle (*Dryocoetes confusus* SW). The fir engraver (*Scolytus ventralis* LeConte) may at times be very destructive locally (Furniss and Carolin 1977). In the Cascades, the balsam woolly aphid (*Adelges piceae* Ratzeburg), introduced from Europe, is the most destructive insect pest. This insect has caused significant mortality to subalpine fir, virtually eliminating it from some stands in Oregon and southern Washington (Franklin and Mitchell 1967).

Diseases.—Fir broom rust (*Melampsorella caryophyllacearum* Schroct.) and wood-rotting fungi are responsible for most disease losses (Bier et al. 1948, Hinds et al. 1960, Peterson 1963). Important root and butt rots are *Gloeocystidiellum radiosum* (Fr.) Boid., *Coniophora pu-*

teana (Schum. Fr.) Karst., *Armillaria mellea* (Vahl. ex Fr.) Quel., *Coniophorella olivacea* (Fr.) Karst., *Polyporus tomentosus* var. *circinatus* (Fr.) Satory et. Marre, and *Pholiota squarrosa* (Fr.) Kumm. Important trunk rots are *Haematostereum sanguinolentum* (Arb. ex Schw. ex Fr.) Pouz., *Phellinus pini* (Tore ex Fr.) Pilat, and *Amylostereum chailletii* (Pers. ex Fr.) Boid. Wood rots and broom rust weaken affected trees and predispose them to windthrow and windbreak.

Fire.—Subalpine fir bark is thin, especially on younger trees; lower limbs persist after death. These characteristics make subalpine fir susceptible to death or severe injury from fire.

PROPERTIES AND USES OF THE WOOD

Subalpine fir wood is light in weight, low in bending and compressive strength, moderately limber, soft, and low in resistance to shock. Shrinkage of wood is rated low to moderately high. It is easy to work, glues well, and holds nails and screws fairly well (USDA Forest Service 1955).

Fir is used as lumber in building construction, boxes, crates, planing mill products, sashes, doors, frames, and food containers. It has not been widely used for pulpwood because of inaccessibility, but it can be pulped readily by the sulfate, sulfite, or groundwood processes (USDA Forest Service 1955).

GENETICS

Population Differences

Information on subalpine fir population differences is virtually nonexistent. Undoubtedly any species with the range in elevation and latitude of subalpine fir will exhibit ecotypic variations in growth, phenology, dormancy, resistance to heat and cold, etc., among different populations.

Races and Hybrids

Corkbark fir is the only recognized natural geographical variety of subalpine fir (Little 1979). Like many species with wide distribution, unknown races and hybrids have probably developed , and there is some evidence that natural introgressive hybridization between subalpine fir and balsam fir occurs where they grow together in Canada. Horticultural and ornamental cultures have been recognized (Liu 1971). These include: (1) *Abies lasiocarpa* cv. *beissneri*, a dwarf tree bearing distorted branches and twisted needles; (2) *Abies lasiocarpa* cv. *coerulescens*, a beautiful tree with specially intensive bluish needles; (3) *Abies lasiocarpa* cv. *compacta*, a dwarf tree of compact habit.

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APPENDIX

Habitat types, community types, and plant communities in which *Abies lasiocarpa* is a major climax, co-climax, minor climax, or major seral

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
			Abies lasiocarpa series			
Abies lasiocarpa / *Acer glabrum* H.T.	Mountains of central and southern Idaho, northern and central Utah, and northwestern Wyoming; mountains of northern New Mexico	Warm moist	Climax	*Picea engelmannii* *Pseudotsuga menziesii* *Pinus contorta* *Populus tremuloides* *Abies concolor* *Picea pungens*	*A. glabrum* *Thalictrum occidentale* *Thalictrum fendleri* *Osmorhiza chilensis* *Arnica cordifolia* *Berberis repens*	Alexander et al. 1984b[1] Mauk and Henderson 1984 Steele et al. 1981 Steele et al. 1983 Youngblood 1984[2]
Abies lasiocarpa / *Alnus sinuata* H.T.	Mountains of northern Montana and central Idaho	Cool moist	Climax	*P. engelmannii* *P. menziesii* *P. contorta* *Larix occidentalis*	*A. sinuata* *Xerophyllum tenax* *Vaccinium scoparium* *Vaccinium globulare*	Pfister et al. 1977 Steele et al. 1981
Abies lasiocarpa / *Berberis repens* H.T.	Mountains of Utah, northwestern Wyoming, and southeastern Idaho	Warm-cool well-drained	Climax	*P. engelmannii* (minor climax) *P. contorta* *P. pungens* *P. menziesii* *Pinus flexilis* *A. concolor* *P. tremuloides*	*B. repens* *Ribes montigenum* *Carex geyeri* *Pachistima myrsinites* *Symphoricarpos oreophilus*	Mauk and Henderson 1984 Pfister 1972 Steele et al. 1983 Youngblood 1984[2]
Abies lasiocarpa / *Clematis pseudoalpina* H.T.	Mountains of Montana, east of Continental Divide	Warm dry	Climax	*P. engelmannii* *P. flexilis* *P. contorta* *P. menziesii*	*C. pseudoalpina* *Clematis tenuiloba*	Pfister et al. 1977
Abies lasiocarpa / *Juniperus communis* H.T.	Mountains of central Idaho, northwestern Wyoming, Utah, northern Arizona, and New Mexico	Warm to cold dry	Climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. menziesii* *P. contorta* *P. tremuloides* *A. concolor* (NM,AZ) *P. pungens* (UT) *Pinus longaeva* (UT)	*J. communis* *Pyrola secunda* *Shepherdia canadensis* *A. cordifolia* *S. oreophilus* *Rosa woodsii*	Mauk and Henderson 1984 Moir and Ludwig 1979 Steele et al. 1981 Steele et al. 1983 Youngblood 1984[2]
Abies lasiocarpa / *Linnaea borealis* H.T. *A. lasiocarpa-Picea engelmannii* / *L. borealis* P.C.(CO)	Mountains of north central Washington, Montana, central and southern Idaho, northwestern Wyoming, and central Colorado	Cool moist to well-drained	Climax or co-climax with *P. engelmannii*	*P. engelamnnii* *P. contorta* *P. menziesii* *P. tremuloides* *A. concolor*	*L. borealis* *V. scoparium* *Calamagrostis rubescens* *A. cordifolia*	Pfister et al. 1977 Steele et al. 1981 Steele et al. 1983 Steen and Dix 1974[3] Williams and Lillybridge 1983
Abies lasiocarpa / *Menziesia ferruginea* H.T.	Mountains of southeastern Washington, eastern Oregon, Montana, Idaho, and northwestern Wyoming	Cool moist	Climax	*P. engelmannii* *P. contorta* *P. menziesii* *L. occidentalis* *Pinus monticola*	*M. ferruginea* *Rhododendron albiflorum* *Ledum glandulosum* *V. globulare* *Arnica latifolia* *X. tenax*	Cooper et al. 1983[4] Daubenmire and Daubenmire 1968 Pfister et al. 1977 Steele et al. 1981 Steele et al. 1983

APPENDIX—Continued

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
Abies lasiocarpa / *Oplopanax horridum* H.T.	Mountains of northern Montana	Cool moist-wet	Co-climax with *P. engelmannii*	*P. engelmannii* *P. monticola* *P. menziesii* *L. occidentalis*	*O. horridum* *Taxus brevifolia*	Pfister et al. 1977
Abies lasiocarpa / *Pachistima myrsinites* H.T. *A. lasiocarpa-Picea engelmannii* / *P. myrsinites* H.T.	Mountains of southern British Columbia and north-central Washington; Rocky Mountains and associated ranges of Canada, south to southern Colorado	Warm dry to well-drained	Climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. menziesii* *P. contorta* *P. monticola* *L. occidentalis* *P. tremuloides*	*P. myrsinites* *Clintonia uniflora* *Galium triflorum* *C. geyeri* *Erigeron* spp.	Daubenmire and Daubenmire 1968 Hess and Wasser 1982[5] McLean 1970 Steen and Dix 1974[3] Williams and Lillybridge 1983
Abies lasiocarpa / *Physocarpus malvaceus* H.T.	Mountains of eastern Idaho, northwestern Wyoming, and northern and central Utah	Warm moist	Climax	*P. engelmannii* *P. contorta* *P. menziesii* *P. tremuloides*	*P. malvaceus* *Symphoricarpos albus* *Spiraea betulifolia* *Amelanchier alnifolia* *Sorbus scopulina*	Mauk and Henderson 1984 Steele et al. 1983 Youngblood 1984[2]
Abies lasiocarpa / *Phyllodoce emptriformis* P.C.	Eastside Cascades, north-central Washington	Cool moist	Co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* *Pinus albicaulis*	*P. emptriformis* *V. scoparium*	Williams and Lillybridge 1983
Abies lasiocarpa / *Ribes montigenum* H.T.	Mountains of southern Montana, Idaho, Utah, and northwestern Wyoming	Cool dry	Climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* *P. tremuloides*	*R. montigenum* *A. latifolia* *T. fendleri* *Antennaria microphylla* *Mertensia arizonica*	Mauk and Henderson 1984 Pfister 1972 Pfister et al. 1977 Steele et al. 1981 Steele et al. 1983 Youngblood 1984[2]
Abies lasiocarpa / *Rhododendron albiflorum* P.C.	Eastside Cascades, north-central Washington	Cool moist	Co-climax with *P. engelmannii*	*P. engelmannii* *P. menziesii* *P. contorta*	*R. albiflorum* *L. glandulosum*	Williams and Lillybridge 1983
Abies lasiocarpa / *Rubus parviflorus* H.T.	Mimbres and Mogollon Mountains, New Mexico; San Juan Mountains, Colorado	Cool moist	Co-climax with *P. engelmannii*	*P. engelmannii* *P. menziesii* (NM) *A. concolor* (NM) *P. tremuloides*	*R. parviflorus* *Vaccinum myrtillus* *A. glabrum* *P. myrsinites*	DeVelice et al. 1984[6] Fitzhugh et al. 1984[7] Moir and Ludwig 1979
Abies lasiocarpa / *Salix glauca* H.T. *A. lasiocarpa-Picea engelmannii* / *S. glauca* H.T.	High mountains of Colorado	Cold wet	Co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* *P. flexilis*	*S. glauca* *V. myrtillus* *Polemonium pulcherrimum* *Acomastylis rossii*	Hess 1981 Hess and Wasser 1982[5] Komarkova 1984[8]
Abies lasiocarpa / *Shepherdia canadensis* H.T. (WY) *A. lasiocarpa-Picea engelmannii* / *S. canadensis* P.C.(CO)	Bighorn Mountains, Wyoming; high mountains of central Colorado	Cool-warm dry	Co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* *P. tremuloides* *P. menziesii*	*S. canadensis* *V. scoparium*	Hoffman and Alexander 1976 Steen and Dix 1974[3]
Abies lasiocarpa / *Spiraea betulifolia* H.T.	Mountains of central and southern Idaho and northwestern Wyoming	Warm dry	Climax	*P. engelmannii* *P. menziesii* *P. contorta* *P. albicaulis*	*S. betulifolia* *P. myrsinites* *C. rubescens*	Steele et al. 1981 Steele et al. 1983

APPENDIX—Continued

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
Abies lasiocarpa / Symphoricarpos albus H.T.	Mountains of southeast Idaho and northwestern Wyoming	Warm well-drained	Climax	*P. engelmannii* *P. menziesii* *P. contorta* *P. tremuloides*	*S. albus* *A. alnifolia* *C. rubescens*	Steele et al. 1983
Abies lasiocarpa / Vaccinium caespitosum H.T.	Mountains of Montana, central Idaho, and northern and central Utah	Cool well-drained	Climax	*P. engelmannii* *P. contorta* *P. tremuloides*	*V. caespitosum* *L. borealis* *C. rubescens* *V. scoparium* *A. cordifolia*	Mauk and Henderson 1984 Pfister et al. 1977 Steele et al. 1981 Youngblood 1984[2]
Abies lasiocarpa / Vaccinium globulare H.T.	Mountains of south-central Montana, central and southern Idaho, north-ern, Utah, and northwestern Wyoming	Cool well-drained	Climax	*P. engelmannii* *P. contorta* *P. menziesii* *P tremuloides*	*V. globulare* *V. scoparium* *Lonicera utahensis* *P. myrsinites*	Mauk and Henderson 1984 Pfister et al. 1977 Steele et al. 1981 Steele et al. 1983
Abies lasiocarpa / Vaccinium membranaceum H.T.(UT); P.C.(OR,WA)	Blue Mountains; Washington and Oregon; mountains of central Utah	Warm dry to well-drained	Climax	*P. engelmannii* *P. menziesii* *L. occidentalis*	*V. membranaceum* *P. myrsinites* *A. cordifolia* *Carex rossii*	Hall 1973 Youngblood 1984[2]
Abies lasiocarpa / Vaccinium myrtillus H.T. [*A. lasiocarpa / V. myrtillis Linnaea borealis* H.T.] [*A. lasiocarpa / V. myrtillis-Rubus parviflorus* H.T.] [*A. lasiocarpa / Vaccinium scoparium-L. borealis* H.T.]	Mogollon Plateau, Arizona; mountains of northern New Mexico and southern Colorado; La Sal Mountains, Utah	Cool moist to well-drained	Climax (AZ) co-climax with *P. engelmannii* (NM,CO,UT)	*P. engelmannii* *Pinus aristata* *P. tremuloides* *P. menziesii* *A. concolor* *P. flexilis*	*V. myrtillus* *Disporum trachycarpum* *Calamagrotis canadensis* *Polemonium flavum* *V. scoparium* *L. borealis* *R. parviflorus*	Alexander et al. 1984b[1] DeVelice et al. 1984[6] Fitzhugh et al. 1984[7] Moir and Ludwig 1979 Youngblood 1984[2]
Abies lasiocarpa / Vaccinium scoparium H.T. *A. lasiocarpa-Picea engelmannii / V. scoparium* H.T. [*P. engelmannii / V. scoparium* H.T.	Mountains of British Columbia and Alberta south to Arizona and New Mexico; mountains of eastern Oregon and eastern and north-central Washington	Cool dry	Climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* *L. occidentalis* *P. tremuloides* *P. menziesii* *P. albicaulis* *P. pungens* *A. concolor*	*V. scoparium* *C. rubescens* *V. myrtillus* *A. cordifolia* *C. geyeri* *Erigeron superbus* (*E. eximius*) *L. borealis* *P. myrsinites* *P. empetriformis*	Daubenmire and Daubenmire 1968 Hall 1973 Hess 1981 Hess and Wasser 1982[5] Hoffman and Alexander 1976 Hoffman and Alexander 1980 Hoffman and Alexander 1983 Komarkova 1984[8] Mauk and Henderson 1984 McLean 1970 Pfister 1972 Pfister et al. 1977 Steele et al. 1981 Steele et al. 1983 Steen and Dix 1974[3] Williams and Lillybridge 1983 Wirsing and Alexander 1975
A. lasiocarpa-Pinus albicaulis / Vaccinium scoparium H.T.	Mountains of Montana east of Continental Divide	Cool dry	Co-climax with *P. albicaulis*	*P. albicaulis* *P. engelmannii* *P. contorta*	*V. scoparium* *X. tenax* *C. geyeri* *A. latifolia*	Pfister et al. 1977

APPENDIX—Continued

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
Abies lasiocarpa / *Vaccinium* spp. P.C.	Eastside Cascades, north-central Washington	Cool dry	Co-climax with *P. engelmannii* *P. menziesii*	*P. engelmannii* *P. menziesii* *P. contorta* *L. occidentalis*	*Vaccinium* spp. *C. rossii* *P. myrsinites* *Arctostaphylos uva-usi*	Williams and Lillybridge 1983
Abies lasiocarpa / *Xerophyllum tenax* H.T.	Mountains of northern Idaho and eastern Washington and Oregon, south to southern Idaho, Montana, and northwestern Wyoming	Warm dry	Climax	*P. engelmannii* *P. albicaulis* *P. contorta* *P. menziesii*	*X. tenax* *V. membranaceum* *V. scoparium* *V. globulare* *Luzula hitchcockii*	Cooper et al. 1983[4] Daubenmire and Daubenmire 1968 Pfister et al. 1977 Steele et al. 1981 Steele et al. 1983
Abies lasiocarpa / *Calamagrostis canadensis* H.T. *A. lasiocarpa-Picea engelmannii* / *C. canadensis* H.T. [*P. engelmannii* / *C. canadensis* H.T.]	Mountains of central Montana, Idaho, northwestern Wyoming, northern Utah, and north-central and western Colorado	Cool wet	Climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* *P. tremuloides* *P. menziesii*	*C. canadensis* *G. triflorum* *V. caespitosum* *L. glandulosum* *Senecio triangularis*	Cooper et al. 1983[4] Hess 1981 Komarkova 1984[6] Mauk and Henderson 1984 Pfister et al. 1977 Steele et al. 1981 Steele et al. 1983
Abies lasiocarpa / *Calamagrostis ruibescens* H.T.	Mountains of north-central Washington, Montana east of Continental Divide, central and southern Idaho, northern Utah, and northwestern Wyoming	Warm dry	Climax	*P. engelmannii* *P. contorta* *P. menziesii* *P. tremuloides*	*C. rubescens* *O. chilensis* *T. occidentale* *C. geyeri* *A. cordifolia* *P. myrsinites*	Mauk and Henderson 1984 Pfister et al. 1977 Steele et al. 1981 Steele et al. 1983 Williams and Lillybridge 1983
Abies lasiocarpa / *Luzula hitchcockii* H.T.	Mountains of Montana west of Continental Divide, Idaho, and northwestern Wyoming	Cool well-drained	Climax	*P. engelmannii* *P. albicaulis* *P. contorta*	*L. hitchcockii* *A. latifolia* *X. tenax* *A. cordifolia* *M. ferruginea* *V. scoparium*	Cooper et al. 1983[4] Pfister et al. 1977 Steele et al. 1981 Steele et al. 1983
Abies lasiocarpa / *Carex geyeri* H.T. *A. lasiocarpa-Picea engelmannii* / *C. geyeri* H.T. [*P. engelmannii* / *C. geyeri* H.T.	Mountains of central Montana, central Idaho, southern Utah, northwestern Wyoming southern Wyoming, and north-central and western Colorado	Warm to cool, dry	Climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* *P. menziesii* *P. albicaulis* *P. tremuloides*	*C. geyeri* *S. oreophilus* *A. cordifolia* *Lupinus argenteus* *B. repens* *Lathyrus lanszwertii*	Hess 1981 Hess and Wasser 1982[5] Hoffman and Alexander 1975 Hoffman and Alexander 1983 Komarkova 1984[6] Pfister et al. 1977 Steele et al. 1981 Steele et al. 1983 Steen and Dix 1974[3] Wirsing and Alexander 1975 Youngblood 1984[2]
Abies lasiocarpa-Pinus albicaulis / *Carex geyeri* P.C.	Mountains of southeastern Washington and eastern Oregon	Cool dry	Co-climax with *P. albicaulis*	*P. albicaulis* *P. engelmannii*	*C. geyeri* *L. argenteus* *Arenaria aculeata* *A. latifolia* *V. scoparium*	Hall 1973
Abies lasiocarpa / *Carex rossii* H.T.	Mountains of southern Idaho, Utah, and northwestern Wyoming	Warm dry	Climax	*P. engelmannii* *P. contorta* *P. tremuloides* *P. menziesii*	*C. rossii* *A. cordifolia* *Astragalus miser* *R. woodsii*	Steele et al. 1983 Youngblood 1984[2]

APPENDIX—Continued

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
Abies lasiocarpa-Pinus albicaulis H.T.	Mountains of northern Idaho and eastern Washington and Oregon	Cool dry	Co-climax with *P. albicaulis*	*P. albicaulis*	*V. scoparium* *X. tenax* *C. geyeri* *Luzula glabrata*	Daubenmire and Daubenmire 1968
Abies lasiocarpa / Aconitum columbianum H.T.	Mountains of central and southern Utah	Cool moist	Climax	*P. engelmannii* *P. menziesii* *P. tremuloides* *A. concolor*	*A. columbianum* *Actaea rubra* *A. cordifolia* *Bromus ciliatus*	Youngblood 1984[2]
Abies lasiocarpa / Actaea rubra H.T.	Mountains of central Idaho, northern Utah, and northwestern Wyoming	Warm moist lower slopes	Co-climax with *P. engelmannii*	*P. engelmannii* *P. pungens* *P. menziesii* *P. contorta* *P. tremuloides*	*A. rubra* *O. chilensis* *L. utahensis* *V. globulare*	Mauk and Henderson 1984 Steele et al. 1983
Abies lasiocarpa / Arnica cordifolia H.T.	Mountains of Montana east of Continental Divide, central Idaho, and northwestern and north-central Wyoming	Cool well-drained	Climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* *P. albicaulis* *P. menziesii* *P. tremuloides*	*A. cordifolia* *P. secunda* *A. miser* *Fragaria virginiana*	Hoffman and Alexander 1976 Komarkova 1984[8] Pfister et al. 1977 Steele et al 1981 Steele et al. 1983
Abies lasiocarpa / Arnica latifolia H.T.	Mountains of southern Idaho, northern Utah, and northwestern Wyoming	Cool dry	Co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* *P. tremuloides* *P. menziesii* *P. albicaulis*	*A. latifolia* *Aster engelmannii* *Pedicularis racemosa*	Steele et al. 1983
Abies lasiocarpa / Caltha biflora H.T.	Mountains of central Idaho	Cool wet	Co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta*	*C. biflora* *Lonicera involucrata* *Pedicularis bracteosa* *Dodecatheon jeffreyi*	Steele et al. 1981
Abies lasiocarpa-Picea engelmannii / Cardamine cordifolia P. C. [*A. lasiocarpa /Mertensia ciliata* H.T.]	Mountains of central and southern Colorado	Cool wet	Co-climax with *P. engelmannii*	*P. engelmannii* *P. tremuloides*	*C. cordifolia* *Mertensia ciliata* *Mitella pentandra* *Carex* spp.	DeVelice et al. 1984[6] Steen and Dix 1974[3]
Abies lasiocarpa / Clintonia uniflora H.T.	Mountains of northwestern Montana and northern and central Idaho	Warm moist to cool dry	Climax	*P. engelmannii* *P. contorta* *P. menziesii* *L. occidentalis* *P. monticola*	*C. uniflora* *M. ferruginea* *V. caespitosum* *Aralia nudicaulis* *X. tenax*	Cooper et al. 1983[4] Pfister et al. 1977 Steele et al. 1981
Abies lasiocarpa / Coptis occidentalis H.T.	Mountains of northern and central Idaho	Warm well-drained	Climax	*P. engelmannii* *P. contorta* *P. menziesii* *L. occidentalis*	*C. occidentalis* *X. tenax* *V. globulare* *M. ferruginea*	Cooper et al. 1983[4] Steele et al. 1981
Abies lasiocarpa / Erigeron superbus (E. eximius) H.T.	Mountains of southwest Colorado, northern New Mexico, and Arizona	Cool dry	Co-climax with *P. engelmannii*	*P. engelmannii* *P. menziesii* *A. concolor* *P. ponderosa* *Pinus strobiformis* *P. tremuloides*	*E. superbus (E. eximius)* *Geranium richardsonii* *Lathyrus arizonicus* *L. involucrata* *A. cordifolia*	Alexander et al. 1984a DeVelice et al. 1984[6] Fitzhugh et al. 1984[7] Moir and Ludwig 1979
Abies lasiocarpa / Galium triflorum H.T.	Mountains of northern Montana	Warm moist	Climax	*P. engelmannii* *P. contorta* *P. menziesii* *L. occidentalis*	*G. triflorum* *A. rubra* *Streptopus amplexifolius*	Pfister et al. 1977

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
Abies lasiocarpa / Lathyrus arizonicus H.T. [*A. lasiocarpa-Pinus strobiformis / L. arizonicus* H.T.	San Francisco, Peaks Arizona; Mogollon Mountains, New Mexico	Cool dry	Climax	*P. strobiformis* *P. tremuloides* *P. menziesii*	*L. arizonicus* *G. richardsonii* *Smilacina stellata* *A. glabrum* *S. oreophilus* *Vicia americana*	Moir and Ludwig 1979 Fitzhugh et al. 1984[7]
Abies lasiocarpa-Picea engelmannii / Lupinus argenteus P.C.	Mountains of central and southern Colorado	Warm well-drained	Co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* (long-lived seral)	*L. argenteus* *V. scoparium*	Steen and Dix 1974[3]
Abies lasiocarpa / Osmorhiza chilensis H.T.	Mountains of southern Idaho and northern Utah	Warm moist to well-drained	Climax	*P. engelmannii* *P. menziesii* *P. contorta* *P. tremuloides*	*O. chilensis* *C. rossii* *B. repens* *P. myrsinites*	Mauk and Henderson 1984 Steele et al. 1983
Abies lasiocarpa / Pedicularis racemosa H.T.	Mountains of southeast Idaho, northwestern Wyoming, and northern Utah	Warm dry	Climax	*P. engelmannii* *P. contorta* *P. menziesii* *P. tremuloides*	*P. racemosa* *A. cordifolia* *S. oreophilus*	Mauk and Henderson 1984 Steele et al. 1983
Abies lasiocarpa / Polemonium delcatum H.T. *A. lasiocarpa-Picea engelmannii / P. delicatum* P.C.	Mountains of central and western Colorado	Cool dry	Co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* *P. tremuloides*	*P. delicatum* (*P. pulcherrimum*) *Osmorhiza obtusa* *Vaccinium* spp.	Komarkova 1984[8] Steen and Dix 1974[3]
Abies lasiocarpa / Senecio sanguisorboides H.T.	Sacramento Mountains, southern New Mexico	Cool dry to well-drained	Co-climax with *P. engelmannii*	*P. engelmannii* *P. menzieisi* *P. tremuloides*	*S. sanguisorboides* *R. montigenum* *Ribes wolfii*	Alexander et al. 1984a Moir and Ludwig 1979
Abies lasiocarpa / Senecio triangularis H.T. *A. lasiocarpa-Picea engelmannii S. triangularis* H.T. [*P. engelmannii / S. triangularis* H.T.]	Mountains of north-central and western Colorado	Warm wet stream bottoms	Co-climax with *P. engelmannii*	*P. engelmannii*	*S. triangularis* *C. cordifolia* *Equisetum arvense* *M.ciliata*	Hess 1981 Komarkova 1984[8]
Abies lasiocarpa / Streptopus amplexifolius H.T.	Mountains of central Idaho and northwestern Utah	Warm moist to wet	Climax	*P. engelmannii*	*S. amplexifolius* *S. triangularis* *Ligusticum canbyi* *Ribes lacustre*	Cooper et al. 1983[4] Steele et al. 1981 Steele et al. 1983
Abies lasiocarpa / Thalictrum occidentale H.T.	Mountains of southeastern Idaho and north-western Wyoming	Warm well-drained	Climax	*P. engelmannii* *P. menziesii* *P. contorta* *P tremuloides*	*T. occidentale* *O. chilensis* *A. cordifolia*	Steele et al. 1983
Abies lasiocarpa / Moss spp. H.T. *A. lasiocarpa-Picea engelmannii /* Moss spp. P.C.	Mountains of central, and southwestern Colorado, and northern New Mexico	Cool dry to well-drained	Co-climax with *P. engelmannii*	*P. engelmannii* *P. aristata* *P. tremuloides* *P. contorta*	Moss spp. *V. caespitosum* *Rosa* spp.	DeVelice et al. 1984[6] Komarkova 1984[8] Steen and Dix 1974[3]
Abies lasiocarpa / Scree H.T.	Mountains of northern New Mexico and southern Colorado	Warm dry	Climax	*P. menziesii* *P. strobiformis*	*S. oreophilus* *J. communis* *Holodiscus dumosus* *L. involucrata* *Erigeron vetensis*	DeVelice et al. 1984[6] Fitzhugh et al. 1984[7]

APPENDIX—Continued

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
			Picea engelmannii series			
Picea engelmannii / Acer glabrum	Sacremento Mountains, New Mexico; Chiricahua Mountains, Arizona	Warm moist	Minor climax to *P. englemannii*	*P. englemannii* *P. menziesii* *P. tremuloides*	*A. glabrum* *B. ciliatus* *Viola canadensis* *S. stellata*	Alexander et al. 1984a Moir and Ludwig 1979
Picea engelmannii / Physocarpus malvaceus H.T.	Mountains of south-central Montana	Warm moist	Minor climax to *P. engelmannii*	*P. engelmannii* *P. menziesii* *P. contorta*	*P. malvaceus* *S. albus* *S. betulifolia*	Pfister et al. 1977
Picea engelmannii / Vaccinium myrtillus H.T. [*P. engelmannii / V. myrtillus-Polemonium pulcherrimum* H.T.] *P. engelmannii / Vaccinium scoparium-P. delicatum* H.T.]	Sangre de Cristo Mountains, southern Colorado and northern New Mexico	Cool dry	Minor climax to *P. engelmannii*	*P. engelmannii* *P. tremuloides* *P. aristata*	*V. myrtillus* *P. delicatum* (*P. pulcherrimum*) *Senecio* spp. *Deschampsia caespitosa* *Poa reflexa*	DeVelice et al. 1984[6] Fitzhugh et al. 1984[7] Moir and Ludwig 1979
Picea engelmannii / Vaccinium scoparium H.T.	Mountains of northwestern Wyoming	Cool dry	Minor climax to *P. engelmannii*	*P. engelmannii* *P. contorta* *P. flexilis* *P. albicaulis*	*V. scoparium* *A. cordifolia* *Antenaria* spp. *Lupinus* spp.	Steele et al. 1983
Picea engelmannii / Elymus triticoides H.T.	Capitan Mountains, New Mexico	Cool dry to well-drained	Minor climax to or co-climax with *P. engelmannii*	*P. engelmannii* *P. menziesii*	*E. triticoides* *A. glabrum* *Jamesia americana*	Alexander et al. 1984a Moir and Ludwig 1979
Picea engelmannii / Carex disperma H.T.	Mountains of central and southern Idaho and western Wyoming	Cool moist	Minor climax to *P. engelmannii*	*P. engelmannii* *P. contorta* *P. pungens*	*C. disperma* *P. secunda* *G. triflorum*	Steele et al. 1981 Steele et al. 1983
Picea engelmannii / Caltha leptosepala H.T.	Mountains of northwestern Wyoming and east-central Idaho	Warm moist	Minor climax to *P. engelmannii*	*P. engelmannii* *P. contorta*	*C. leptosepala* *Trollius taxus*	Steele et al. 1983
Picea engelmannii / Equisetum arvense H.T.	Mountains of southern Montana, northwestern Wyoming, central Idaho, and northern Utah	Warm to cool, wet	Minor climax to *P. engelmannii*	*P. engelmannii* *P. contorta* *P. pungens*	*E. arvense* *S. amplexifolius* *S. triangularis* *Luzula parviflora*	Mauk and Henderson 1984 Steele et al. 1983
Picea engelmannii / Galium trifolium H.T.	Mountains of central Idaho and northwestern Wyoming	Warm moist	Minor climax to *P. engelmannii*	*P. engelmannii* *P. contorta* *P. menziesii* *P. pungens*	*G. trifolium* *A. rubra* *S. stellata* *S. amplexifolius*	Steele et al. 1981 Steele et al. 1983
Picea engelmannii / *Senecio cardamine* H.T.	Blue Mountains, Arizona	Cool moist	Seral to *P. engelmannii*	*P. engelmannii* *P. menziesii* *P. pungens* *Pinus ponderosa* *P. strobiformis* *A. concolor* *P. tremuloides*	*S. cardimine* *Fragaria ovalis* *G. richardsonii* *V. canadensis*	Fitzhugh et al. 1984[7]
Picea engelmannii / Trifolium dasyphyllum H.T.	Mountains of north-central Colorado	Cold dry	Minor climax to or co-climax with *P. engelmannii*	*P. engelmannii* *P. tremuloides*	*T. dasyphyllum* *Pyrola chlorantha* *Sedum lanceolatum*	Hess 1981
Picea engelmannii / Moss spp. H.T.	Mountains of northern New Mexico	Cool dry to well-drained	Co-climax with *P. engelmannii*	*P. engelmannii* *P. aristata* *P. tremuloides* *P. menziesii*	Moss spp. *Ribes* spp. *Vaccinium* spp. *L. arizonicus*	Alexander et al. 1984b[1] Fitzhugh et al. 1984[7] Moir and Ludwig 1979

APPENDIX—Continued

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
Picea engelmannii / Scree H.T.	Mountains of northern New Mexico and southern Colorado	Warm dry	Minor climax to *P. engelmannii*	*P. engelmannii*	*J. communis* *Saxifrage bronchialis*	DeVelice et al. 1984[6]
			Picea pungens series			
Picea pungens / *Amelanchier alnifolia* H.T.	Mountains of central and western Colorado	Warm moist	Minor climax to *P. pungens*	*P. pungens* *P. menziesii* *Populus angustifolia*	*A. alnifolia* *Cornus stolonifera* *C. geyeri* *Swida sericea*	Hess and Wasser 1982[5] Komarkova 1984[6]
Picea pungens / *Erigeron eximus* H.T. [*P. pungens*-*Picea engelmannii* /*E. superbus* H.T.]	White Mountains, Arizona	Cool dry	Minor climax to *P. engelmannii* *P. pungens*	*P. pungens* *P. engelmannii* *P. menziesii* *P. ponderosa* *P. strobiformis* *P. tremuloides* *P. concolor*	*E. superbus* (*E. eximius*) *Festuca arizonica* *Carex foenea* *F. virginiana*	Moir and Ludwig 1979
Picea pungens / *Senecio cardamine* H.T. [*P. pungens*-*Picea engelmannii* /*S. cardamine* H.T.]	White Mountains, Arizona	Cool moist	Co-climax with or minor climax to *P. engelmannii* *P. pungens*	*P. engelmannii* *P. pungens* *P. ponderosa* *P. menziesii* *P. strobiformis* *P. tremuloides* *A. concolor*	*S. cardamine* *Pteridium aquilinum* *Helenium hoopesii* *V. canadensis*	Fitzhugh et al. 1984[7] Moir and Ludwig 1979
			Pinus contorta series and other P. contorta dominated vegetation			
Pinus contorta / *Alnus crispa* P.C.	Mountains of Alberta and southern British Columbia	Cool moist to well-drained	Co-climax with *Picea glauca* *P. engelmannii*	*P. glauca* *P. engelmannii* *P. contorta*	*A. crispa* *Cornus canadensis* *A. uva-ursi* *L. borealis* *A. cordifolia* *Vaccinium myrtilloides*	Corns 1978 Corns and LaRoi 1976 LaRoi and Hnatiuk 1980 Wali and Krajina 1973
Pinus contorta / *Arctostaphylos uva-ursi* H.T.(UT); P.C.(CO)	Uinta Mountains, Utah; mountains of central Colorado.	Warm dry	Minor climax to *P. contorta* (UT); ultimate climax unknown (CO); probably climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* *P. tremuloides*	*A. uva-ursi* *B. repens* *Sitanion hystrix*	Mauk and Henderson 1984 Steen and Dix 1974[3]
Pinus contorta / *Juniperus communis* H.T.(CO); C.T.(ID,WY)	Mountains of eastern Idaho, northwestern Wyoming, and central Colorado	Warm dry	Minor climax to *P. contorta* (CO); ultimate climax unknown (ID,WY); probably co-climax with *P. engelmannii* *P. menziesii*	*P. engelmannii* *P. menziesii* *P. tremuloides* *P. albicaulis* *P. contorta*	*J. communis* *A. uva-ursi* *S. canadensis* *A. cordifolia*	Hess 1981 Steele et al. 1983
Pinus contorta / *Ledum groenlandicum* P.C.	Mountains of Alberta	Cool moist	Minor climax to *P. engelmannii* *P. glauca* *Picea mariana*	*P. engelmannii* *P. glauca* *P. mariana* *P. contorta* *P. menziesii*	*L. groenlandicum* *V. scoparium* *C. canadensis* *V. membranaceum*	Corns 1978 Corns and LaRoi 1976 LaRoi and Hnatiuk 1980
Pinus contorta / *Linnaea borealis* C.T. (MT, WY); P.C.(CO)	Mountains of Montana east of Continental Divide, northwestern Wyoming, and central Colorado	Cool moist to well-drained	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. menziesii* *P. contorta* *P. tremuloides*	*L. borealis* *V. scoparium* *V. globulare* *A. cordifolia* *C. rubescens*	Pfister et al. 1977 Steele et al. 1983 Steen and Dix 1974[3]
Pinus contorta / *Menziesia glabella* P.C.	Mountains of Alberta	Cool moist	Co-climax with *P. glauca* *P. engelmannii* *P. menziesii*	*P. glauca* *P. engelmannii* *P. menziesii* *P. contorta*	*M. glabella* *V. scoparium* *Rubus pedatus* *L. borealis* *C. canadensis*	Corns 1978 LaRoi and Hnatiuk 1980

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
Pinus contorta / Pachistima myrsinites P.C.	Mountains of central Colorado	Warm dry to well-drained	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. tremuloides* *P. contorta*	*P. myrsinites* *V. scoparium* *J. communis* *L. borealis*	Steen and Dix 1974[3]
Pinus contorta / Purshia tridentata H.T.; C.T.	Mountains of southern Washington, northern and central Oregon, and western Montana	Cool-warm dry to well-drained	Minor climax to *P. contorta* (RM) Seral to *P. contorta* (PNW)	*P. contorta* *P. engelmannii* *P. menziesii* *P. tremuloides* *P. ponderosa*	*P. tridentata* *A. uva-ursi* *C. rossii* *Ribes cereum* *Festuca idahoensis* *Epilobium angustifolium* *Stipa occidentalis* *Carex pensylvanica*	Pfister et al. 1977 Volland 1976 Youngberg and Dalms 1970
Pinus contorta / Shepherdia canadensis C.T.; P.C.	Mountains of southern British Columbia and Alberta, southeastern Idaho, northwestern Wyoming, and central Colorado	Cool-warm dry to well-drained	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii* *P. glauca*	*P. glauca* *P. engelmannii* *P. tremuloides* *P. menziesii* *P. contorta*	*S. canadensis* *A. cordifolia* *J. communis* *L. borealis* *A. uva-ursi*	LaRoi and Hnatiuk 1980 Steen and Dix 1974[3] Steele et al. 1983 Wali and Krajina 1973
Pinus contorta / Spiraea betulifolia C.T.	Mountains of eastern Idaho and northwestern Wyoming	Warm dry	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. menziesii* *P. tremuloides* *P. contorta*	*S. betulifolia* *C. rubescens* *C. geyeri*	Steele et al. 1983
Pinus contorta / Spiraea lucida P.C.	Mountains of Alberta east of Continental Divide	Cold moist	Minor climax to *P. engelmannii* *P. mariana*	*P. engelmannii* *P. mariana* *P. contorta*	*S. lucida* *L. borealis* (codom) *C. rubescens*	Thompson and Kuist 1976
Pinus contorta / Symphoricarpos albus P.C.	Mountains of southwestern Alberta	Warm well-drained	Co-climax with *P. glauca* *P. menziesii* *P. engelmannii*	*P. glauca* *P. menziesii* *P. engelmannii* *P. contorta* *P. tremuloides*	*S. albus* *A. cordifolia* *L. borealis*	Kuchar 1973
Pinus contorta / Vaccinium caespitosum C.T.	Mountains of eastern Montana, Idaho, and northern Utah	Cool well-drained	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. menziesii* *P. contorta*	*V. caespitosum* *V. scoparium* *Festuca ovina* *L. borealis*	Cooper et al. 1983[4] Mauk and Henderson 1984 Pfister et al. 1977 Steele et al. 1981
Pinus contorta / Vaccinium globulare C.T.	Mountains of southern Idaho, northwestern Wyoming, and northern Utah	Cool well-drained	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. menziesii* *P. contorta*	*V. globulare* *L. utahensis* *V. scoparium* *C. rubescens*	Steele et al. 1983
Pinus contorta / Vaccinium membranaceum P.C.	Mountains of southern British Columbia	Cool moist	Minor climax to *P. engelmannii* *P. glauca*	*P. engelmannii* *P. glauca* *A. lasiocarpa* *P. contorta*	*V. membranaceum* *C. canadensis* (codom) *C. uniflora* *L. borealis*	Wali and Krajina 1973
Pinus contorta / Vaccinium myrtilloides P.C.	Foothills of western Alberta	Warm dry to moist	Minor climax to *P. glauca* *P. engelmannii*	*P. glauca* *P. engelmannii* *P. contorta*	*V. myrtilloides* *Cladonia* spp. (codom)	Corns 1978

APPENDIX—Continued

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
Pinus contorta / Vaccinium scoparium C.T.; P.C.(OR,WA)	Mountains of Montana, central Idaho, northwestern Wyoming, northern Utah southern Wyoming and central Colorado; mountains of central and eastern Oregon, and southeastern Washington	Cool to cold dry	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii* *P. menziesii* (RM); seral to *Tsuga mertensiana* (PNW)	*P. menziesii* *P. engelmannii* *T. mertensiana* *P. albicaulis* *P. contorta* *P. tremuloides* *P. flexilis* *Abies grandis* *Tsuga heterophylla* *L. occidentalis*	*V. scoparium* *C. rubescens* *A. cordifolia* *L. argenteus* *B. repens* *C. geyeri* *R. cereum*	Cooper et al. 1983[4] Hall 1973 Mauk and Henderson 1984 Pfister et al. 1977 Steele et al. 1981 Steele et al. 1983 Steen and Dix 1974[3] Wirsing and Alexander 1975 Volland 1976 Youngberg and Dahms 1970
Pinus contorta / Viburnum edule P.C.	Foothills of western Alberta	Warm moist	Minor climax to *P. glauca* *P. engelmannii*	*P. glauca* *P. engelmannii* *P. contorta*	*V. edule* *Rubus pubescens* (codom)	LaRoi and Hnatiuk 1980
Pinus contorta / Xerophyllum tenax C.T.(ID); P.C.(OR)	Mountains of central Oregon and northern Idaho	Warm dry	Co-climax with *T. mertensiana* (OR) ultimate climax unknown (ID)	*T. mertensiana* (OR) *P. monticola* (OR) *P. contorta* *P. engelmannii* (ID) *P. menziesii* (ID)	*X. tenax* *C. pensylvanica* (OR) *L. argenteus* (OR) *Vaccinium* spp. (ID)	Cooper et al. 1983[4] Volland 1976
Pinus contorta / Calamagrostis canadensis C.T.	Uinta Mountains, Utah	Cool moist	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta*	*C. canadensis* *A. cordifolia* *J. communis* *Poa nervosa*	Mauk and Henderson 1984
Pinus contorta / Calamagrostis rubescenes C.T.	Mountains of eastern Washington and Oregon, Montana, Idaho, northeastern Utah, and northwestern Wyoming	Warm dry	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii*, except minor climax to *A. grandis* in the Blue Mountains	*P. engelmannii* *A. menziesii* *P. grandis* *P. contorta* *L. occidentalis* *P. tremuloides*	*C. rubescens* *V. scoparium* *C. geyeri* *A. cordifolia* *A. uva-ursi*	Hall 1973 Pfister et al. 1977 Steele et al. 1983
Pinus contorta / Carex geyeri C.T. (ID,WY) P.C.(CO)	Mountains of central Idaho, northwestern Wyoming, southern Wyoming, and central Colorado	Cool dry	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* *P. menziesii* *P. albicaulis* *P. flexilis* *P. tremuloides*	*C. geyeri* *S. oreophilus* *A. cordifolia* *L. argenteus* *B. repens* *J. communis*	Hess 1981 Hess and Wasser 1982[5] Steele et al. 1981 Steele et al. 1983 Steen and Dix 1974[3] Wirsing and Alexander 1975
Pinus contorta / Carex rossii C.T.	Mountains of northwestern Wyoming	Warm dry	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. albicaulis* *P. contorta* *P. tremuloides*	*C. rossii* *L. argenteus* *P. nervosa*	Steele et al. 1983
Pinus contorta / Arnica cordifolia C.T.	Mountains of eastern Idaho and northwestern Wyoming	Cool dry	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* *P. menziesii* *P. albicaulis* *P. flexilis*	*A. cordifolia* *Antennaria racemosa* *A. miser* *P. secunda*	Steele et al. 1983
Pinus contorta / Lupinus argenteus P.C.	Mountains of central and southern Colorado	Warm dry to well-drained	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. tremuloides* *P. contorta*	*L. argenteus*	Steen and Dix 1974[3]

APPENDIX—Continued

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
Pinus contorta Lichen spp. P.C.	Mountains of central Colorado	Hot dry	Ultimate climax unknown; probably climax	*P. contorta* *P. tremuloides*	Lichen spp.	Steen and Dix 1974[3]
			Populus tremuloides series and other P. tremuloides dominated vegetation			
Populus tremuloides-Abies lasiocarpa / Berberis repens C.T. *P. tremuloides / B. repens* C.T.	Mountains of western Wyoming	Warm to cool. Well-drained	Climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. ponderosa* *P. glauca* *P. contorta* *P. tremuloides*	*B. repens* *S. albus* *P. myrsinites*	Youngblood and Mueggler 1981
Populus tremuloides / Pachistima myrsinites C.T.(ID); P.C.(CO)	Mountains of southeastern Idaho and central and southwestern Colorado	Warm dry	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* *P. tremuloides* *P. menziesii*	*P. myrsinites* *V. scoparium* *C. geyeri* *C. rubescens*	Mueggler and Campbell 1982 Steen and Dix 1974[3]
Populus tremuloides-Abies lasiocarpa / Prunus virginiana C.T. *P. tremuloides / P. virginiana* C.T.	Mountains of western Wyoming	Warm dry	Climax or co-climax with *P. menziesii*	*P. menziesii* *P. contorta* *P. tremuloides*	*P. virginiana* *B. repens* *S. oreophilus* *R. woodsii*	Youngblood and Mueggler 1981
Populus tremuloides-Abies lasiocarpa / Shepherdia canadensis C.T. *P. tremuloides / S. canadensis* C.T.	Mountains of western Wyoming	Cool-dry to well-drained	Climax	*P. contorta* *P. tremuloides*	*S. canadensis* *Geranium viscosissimun* *A. cordifolia* *R. woodsii* *T. fendleri*	Youngblood and Mueggler 1981
Populus tremuloides-Abies lasiocarpa / Symphoricarpos oreophilus C.T. *P. tremuloides / S. oreophilus* C.T.	Mountains of southeastern Idaho, northern Utah, and western Wyoming	Warm well-drained	Ultimate climax unknown; probably climax or co-climax with *P. menziesii* *A. lasiocarpa*	*A. lasiocarpa* *P. menziesii* *A. concolor* *P. tremuloides*	*S. oreophilus* *P. virginiana* *B. repens* *Elymus glaucus* *C. rubescens*	Mauk and Henderson 1984 Mueggler and Campbell 1982 Steele et al. 1983 Youngblood and Mueggler 1981
Populus tremuloides-Pseudotsuga menziesii / Symphoricarpos oreophilus C.T. *P. tremuloides / S. oreophilus* C.T.	Mountains of southeastern Idaho	Warm dry	Ultimate climax unknown; probably minor climax to *P. menziesii*	*P. menziesii* *P. contorta* *P. tremuloides*	*S. oreophilus* *C. rubescens* *Poa pratensis* *C. geyeri*	Mueggler and Campbell 1982
Populus tremuloides-Pinus contorta / Calamagrostis rubescens C.T. *P. tremuloides C. rubescens* C.T.	Mountains of southeastern Idaho	Warm dry	Ultimate climax unknown; probably climax or co-climax with *P. menziesii*	*P. menziesii* *P. contorta* *P. tremuloides*	*C. rubescens* *S. oreophilus* *P. myrsinites* *L. argenteus* *T. fendleri* *G. viscosissimum*	Mueggler and Campbell 1982
Populus tremuloides / Elymus glaucus P.C.	Mountains of central and southwestern Colorado	Warm moist to well-drained	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. contorta* *P. tremuloides*	*E. glaucus* *A. alnifolia* *Symphoricarpos* spp. *Ligusticum porteri*	Steen and Dix 1974[3]
Populus tremuloides / Festuca thurberi P.C.	Mountains of southwestern Colorado	Warm dry	Ultimate climax unknown; probably climax or co-climax with *P. engelmannii*	*P. engelmannii* *P. tremuloides* *P. menziesii* *P. flexilis*	*F. thurberi* *B. repens* *S. oreophilus* *F. ovalis*	Steen and Dix 1974[3]
Populus tremuloides / Poa pratensis C.T.	Mountains of southeastern Idaho	Warm dry	Ultimate climax unknown; probably climax or co-climax with *P. menziesii*	*P. menziesii* *P. tremuloides*	*P. pratensis* *C. rubescens* *T. fendleri* *P. nervosa* *L. argenteus*	Mueggler and Campbell 1982

APPENDIX—Continued

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
Populus tremuloides-Abies lasiocarpa / Arnica cordifolia C.T. *P. tremuloides / A. cordifolia* C.T.	Mountains of western Wyoming	Cool moist to well-drained	Climax	*P. contorta* *P. tremuloides*	*A. cordifolia* *S. oreophilus* *C. rossii* *O. chilensis* *P. nervosa*	Youngblood and Mueggler 1981
Populus tremuloides / Geranium viscosissimum C.T.	Mountains of southeastern Idaho	Warm dry	Climax	*P. tremuloides*	*G. viscosissimum* *Symphoricarpos* spp. *L. argenteus* *T. fendleri*	Mueggler and Campbell 1982
Populus tremuloides / Heracleum lanatum C.T.	Mountains of western Wyoming	Warm moist	Climax	*P. engelmannii* *P. contorta* *P. tremuloides*	*H. lanatum* *P. bracteosa* *T. fendleri* *E. glaucus*	Youngblood and Mueggler 1981
Populus tremuloides-Abies lasiocarpa / Ligusticum filicinum C.T. *P. tremuloides / L. filicinum* C.T.	Mountains of western Wyoming	Cool moist to well-drained	Climax	*P. menziesii* *P. flexilis* *P. tremuloides*	*L. filicinum* *T. fendleri* *G. viscosissimum* *Osmorhiza occidentalis*	Youngblood and Mueggler 1981
Populus tremuloides-Abies lasiocarpa / Pedicularis racemosa C.T.	Mountains of western Wyoming	Cool moist	Climax	*P. engelmannii* *P. tremuloides*	*P. racemosa* *A. cordifolia* *S. oreophilus*	Youngblood and Mueggler 1981
Populus tremuloides / Ranunculus alismaefolius C.T.	Mountains of western Wyoming	Cool moist to wet	Climax	*P. engelmannii* *P. tremuloides*	*R. alismaefolius* *Carex microptera* *Trifolium longipes*	Youngblood and Mueggler 1981
Populus tremuloides-Abies lasiocarpa / Rudbeckia occidentalis C.T. *P. tremuloides / R. occidentalis* C.T.	Mountains of southeastern Idaho and western Wyoming	Cool moist to well-drained	Climax	*P. engelmannii* *P. tremuloides*	*R. occidentalis* *T. longipes* *Nemophila breviflora* *Melica spectabilis* *Symphoricarpos* spp.	Mueggler and Campbell 1982 Youngblood and Mueggler 1981
Populus tremuloides-Abies lasiocarpa / Thalictrum fendleri C.T.	Mountains of southeastern Idaho	Warm moist	Climax	*P. tremuloides*	*T. fendleri* *S. oreophilus* *G. viscosissimum* *O. chilensis*	Mueggler and Campbell 1982
			Pseudotsuga menziesii series			
Pseudotsuga menziesii / Arctostaphylos uva-ursi H.T.	Mountains of southwestern New Mexico	Warm dry	Minor climax to *P. menziesii*	*P. menziesii* *P. ponderosa* *P. tremuloides* *P. strobiformis* *P. flexilis* *P. engelmannii*	*A. uva-ursi* *A. spicatum* *Festuca* spp. *B. sagittata* *Lithospermum ruderale*	Fitzhugh et al. 1984[7]
Pseudotsuga menziesii / Scree H.T.	Mountains of New Mexico	Warm dry	Seral to *P. menziesii*	*P. menziesii* *P. engelmannii* *P. tremuloides* *P. strobiformis*	*Salix* spp. *S. oreophilus* *H. dumosus* *B. ciliatus*	DeVelice et al. 1984[6] Fitzhugh et al. 1984[7]
			Thuja plicata series			
Thuja plicata / Oplopanax horridum H.T.	Mountains of northwestern Montana and southern British Columbia	Warm wet to cool wet	Seral or minor climax to *T. plicata*	*T. plicata* *T. heterophylla* *T. mertensiana* *P. monticola* *Abies amabilis*	*O. horridum* *Athyrium filix-femina* *Gymnocarpium dryopteris*	Brooke et al. 1970 Pfister et al. 1977
Thuja plicata / Clintonia uniflora H.T.	Mountains of northwestern Montana and northern Idaho	Cool to warm dry, bottom-lands	Seral or minor climax to *T. plicata*	*T. plicata* *A. grandis* *P. engelmannii* *P. menziesii* *L. occidentalis* *P. contorta*	*C. uniflora* *M. ferruginea* *A. nudicaulis* *X. tenax*	Cooper et al. 1983[4] Pfister et al. 1977

APPENDIX—Continued

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
			Abies grandis series			
Abies grandis / *Acer glabrum* H.T.	Mountains of central Idaho	Warm moist	Minor climax to *A. grandis*	*A. grandis* *P. contorta* *P. menziesii*	*A. glabrum* *P. malvaceus*	Steele et al. 1981
Abies grandis / *Linnaea borealis* H.T.	Mountains of central Montana	Cool moist to well-drained	Minor climax to *A. grandis*	*A. grandis* *P. contorta* *P. engelmannii* *P. monticola* *P. ponderosa* *P. menziesii* *L. occidentalis*	*L. borealis* *Adenocaulon bicolor* *Disporum hookeri*	Pfister et al. 1977
Abies grandis / *Vaccinium caespitosum* H.T.	Mountains of central Idaho	Cool well-drained	Minor climax to *A. grandis*	*A. grandis* *P. engelmannii* *P. menziesii* *L. occidentalis*	*V. caespitosum* *F. virginiana* *C. rubescens*	Steele et al. 1981
Abies grandis / *Vaccinium globulare* H.T.	Mountains of central Idaho	Cool well-drained	Minor climax to *A. grandis*	*A. grandis* *P. engelmannii* *P. menziesii* *P. contorta*	*V. globulare*	Steele et al. 1981
Abies grandis / *Xerophyllum tenax* H.T.	Mountains of northern Idaho	Cool dry	Minor climax to *A. grandis*	*A. grandis* *P. engelmannii* P. contorta P. ponderosa P. menziesii	*X. tenax* *V. globulare*	Cooper et al. 1983[4]
Abies grandis / *Clintonia uniflora* H.T.	Mountains of western Montana and northern Idaho	Warm moist	Minor climax to *A. grandis*	*A. grandis* *P. menziesii* *P. engelmannii* *L. occidentalis* *P. contorta* *P. ponderosa*	*C. uniflora* *L. borealis* *A. bicolor* *X. tenax* *M. ferruginea*	Cooper et al. 1983[4] Pfister et al. 1977
Abies grandis / *Coptis occidentalis* H.T.	Mountains of northern Idaho	Warm moist	Minor climax to *A. grandis*	*A. grandis* *P. engelmannii* *P. contorta* *P. ponderosa* *P. menziesii* *L. occidentalis*	*C. occidentalis* *V. globulare* *X. tenax* *S. albus*	Cooper et al. 1983[4]
Abies grandis / *Senecio triangularis* H.T.	Mountains of northern Idaho	Warm moist	Minor climax to *A. grandis*	*A. grandis* *P. engelmannii* *L. occidentalis*	*S. triangularis* *A. filix-femina* *Trautvetteria caroliniensis*	Cooper et al. 1983[4]
			Abies concolor series			
Abies concolor / *Vaccinium myrtillus* H.T.	Mountains of northern New Mexico and southern Colorado	Cool dry	Minor climax to *A. concolor* *P. menziesii*	*A. concolor* *P. menziesii* *P. pungens* *P. engelmannii* *P. tremuloides*	*V. myrtillus* *A. uva-ursi* *P. myrsinites* *A. glabrum* *R. paviflorus*	DeVelice et al. 1984[6]
			Abies amabilis series			
Abies amabilis / *Menziesia ferruginea* P.C.	Central Cascades, Oregon and Washington	Cool moist	Seral to *A. amabilis*	*A. amabilis* *T. mertensiana* *Chamaecyparis nootkatensis*	*M. ferruginea* *V. membranaceum*	Franklin 1966
Abies amabilis-*Tsuga mertensiana* / *Xerophyllum tenax* P.C.	Western Cascades, central Oregon	Warm dry	Seral to *A. amabilis* *T. mertensiana*	*A. amabilis* *T. mertensiana* *P. contorta*	*X. tenax* *V. membranaceum*	Franklin and Dyrness 1973
Abies amabilis / *Streptopus roseus* P.C.	Mountains of southern British Columbia	Cool wet	Seral to *A. amabilis*	*A. amabilis* *T. mertensiana* *C. nootkatensis*	*S. roseus*	Brooke et al. 1970

APPENDIX—Continued

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
Abies amabilis / *Veratrum viride* P.C.	Cascades, southern Washington and northern Oregon	Cool wet	Seral to *A. amabilis*	*A. amabilis* *T. mertensiana* *P. menziesii*	*V. viride*	Franklin 1966
			Abies magnifica series			
Abies magnifica / *Leucothoe davisiae* P.C.	Russian Peak, Kalmath Mountains, California	Cool wet	Minor climax to *A. amabilis* *A. magnifica*	*A. magnifica* *A. amabilis* *A. concolor* *Pinus lambertiana* *P. engelmannii* (minor climax) *Picea brewerana* *P. monticola* *Taxus brevifolia* *T. mertensiana* *Libocedrus decurrens*	*L. davisiae* *R. lacustre* *Alnus tenuifolia* *Sorbus californica*	Sawyer and Thornburgh 1977
Abies magnifica / *Linnaea borealis* P.C.	Russian Peak, Klamath Mountains, California	Cool moist open	Minor climax to *A. magnifica*	*A. magnifica* *P. contorta* *P. menziesii* *P. ponderosa* *P. engelmannii* *P. monticola* *T. mertensiana* *A. concolor* *P. lambertiana* *A. amabilis*	*L. borealis* *Poa secunda* *Anemone deltoidea* *Chimaphila umbellata*	Sawyer and Thornburgh 1977
			Tsuga heterophylla series			
Tsuga heterophylla / *Clintonia uniflora* H.T.	Mountains of northwestern Montana and northern Idaho	Warm moist	Minor climax to *T. heterophylla* *T. plicata*	*T. heterophylla* *T. plicata* *P. monticola* *P. contorta* *P. menziesii* *L. occidentalis* *P. engelmannii*	*C. uniflora* *A. nudicaulis* *X. tenax* *M. ferruginea*	Cooper et al. 1983[4] Pfister et al. 1977
			Tsuga mertensiana series			
Tsuga mertensiana / *Cladothamnus pyrolaeflorus* P.C.	Mountains of southern British Columbia	Cool dry	Seral to *T. mertensiana*	*T. mertensiana* *A. amabilis* *P. menziesii*	*C. pyrolaeflorus* *V. membranaceum*	Brooke et al. 1970
Tsuga mertensiana / *Menziesia ferruginea* H.T.	Mountains of southern Washington, northern Idaho, and western Montana; mountains of British Columbia to central Oregon	Cool moist	Minor climax to *T. mertensiana*	*T. mertensiana* *P. engelmannii* *L. occidentalis* *P. contorta* *A. amabilis*	*M. ferruginea* *R. albiflorum* *X. tenax* *L. hitchcockii*	Brockway et al. 1983 Cooper et al. 1983[4] Daubenmire and Daubenmire 1968 Pfister et al. 1977
Tsuga mertensiana / *Rhododendron albiflorium* P.C.	Mountains of southern Washington	Cool moist	Seral to *T. mertensiana*	*T. mertensiana* *P. engelmannii* *T. heterophylla* *A. amabalis* *C. nootkatensis*	*R. albiflorium* *M. ferruginea* *Vaccinium* spp. *P. secunda*	Brockway et al. 1983
Tsuga mertensiana-*Abies amabilis* / *Vaccinium alaskaense* P.C.	Mountains of southern British Columbia	Cool moist	Seral to *T. mertensiana* *A. amabilis*	*T. mertensiana* *A. amabilis* *C. nootkatensis*	*V. alaskaense* *V. membranaceum*	Brooke et al. 1970
T. mertensiana / *Vaccinium membranaceum* P.C. *T. mertensiana*-*A. amabilis* / *V. membranaceum* P.C.	Mountains of British Columbia to central Oregon	Warm dry to well-drained	Seral to *T. mertensiana*	*T. mertensiana* *A. amabilis* *P. contorta* *P. engelmannii*	*V. membranaceum* *X. tenax* *P. secunda*	Brockway et al. 1983 Brooke et al. 1970 Franklin 1966

APPENDIX—Continued

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
Tsuga mertensiana / Vaccinium scoparium P.C.	Mountains of central and northwestern Oregon	Cool dry	Seral or minor climax to *T. mertensiana*	*T. mertensiana* *A. magnifica* *P. monticola* *P. albicaulis* *P. contorta* *P. engelmannii* *A. amabilis* *A. procera*	*V. scoparium* *C. pensylvanica* *L. glabrata* *X. tenax* *V. membranaceum*	Hemstrom et al. 1982 Hopkins 1979 Volland 1976
Tsuga mertensiana / Xerophyllum tenax H.T.	Mountains of northern Idaho, northwestern Montana. Mountains of British Columbia south to central Oregon	Warm dry	Seral to or co-climax with *T. mertensiana*	*T. mertensiana* *P. contorta* *P. menziesii* *P. engelmannii* *P. albicaulis* *P. monticola* *L. occidentalis*	*X. tenax* *V. membranaceum* *V. globulare*	Cooper et al. 1983[4] Daubenmire and Daubenmire 1968 Pfister et al. 1977
Tsuga mertensiana / Clintonia uniflora H.T.	Mountains of northern Idaho	Warm moist	Seral or minor climax to *T. mertensiana*	*T. mertensiana* *P. engelmannii* *P. menziesii* *P. contorta* *L. occidentalis*	*C. uniflora* *X. tenax* *M. ferruginea*	Cooper et al. 1983[4]
Tsuga mertensiana / Luzula hitchcockii H.T.	Mountains of western Montana and northern Idaho	Cool well-drained	Co-climax with *T. mertensiana*	*T. mertensiana* *P. contorta* *P. albicaulis* *P. engelmannii*	*L. hitchcockii* *V. scoparium* *X. tenax* *A. latifolia*	Pfister et al. 1977
Tsuga mertensiana / Phyllodoce empetriformis P.C.	Russian Peak, Klamath Mountains, California	Cool wet	Minor climax to *T. mertensiana*	*T. mertensiana* *P. engelmannii* (minor climax) *P. contorta* *P. monticola* *P. brewerana* *T. brevifolia* *A. concolor* *A. amabilis*	*P. empetriformis* *L. glandulosum* *Kalmia polifolia* *Pyrola picta*	Sawyer and Thornburgh 1977
Tsuga mertensiana / Streptopus amplexifolius H.T.	Mountains of northern Idaho	Warm moist	Seral or minor climax to *T. mertensiana*	*T. mertensiana* *P. engelmannii* *P. menziesii* *L. occidentalis*	*S. amplexifolius* *S. triangularis* *T. caroliniesis* *M. ferruginea*	Cooper et al. 1983[4]
Tsuga mertensiana / Pyrola picta P.C.	Russian Peak, Kalmath Mountains, California	Cool moist	Minor climax to *T. mertensiana*	*T. mertensiana* *A. ambilis* *A. concolor* *P. monticola* *P. flexilis*	*P. picta* *C. umbellata* *Penstemon newberryi* *Arctostaphylos patula* *Arctostaphylos nevadensis*	Sawyer and Thornburgh 1977
			Pinus albicaulis series			
Pinus albicaulis / Vaccinium scoparium H.T.	Mountains of northwestern Wyoming	Cool dry	Minor climax to *P. albicaulis* *P. contorta*	*P. albicaulis* *P. contorta* *P. engelmannii*	*V. scoparium* *A. cordifolia* *C. rossii*	Steele et al. 1983
Pinus albicaulis / Calamagrostis rubescens P.C.	Eastside Cascades, north-central Washington	Cool dry	Seral to *P. albicaulis*	*P. albicaulis* *P. engelmannii* *P. contorta*	*C. rubescens* *P. myrsinites* *V. scoparium*	Williams and Lillybridge 1983
Pinus albicaulis / Carex rossii H.T.	Mountains of northwestern Wyoming	Cool dry	Minor climax to *P. albicaulis*	*P. albicaulis* *P. contorta* *P. engelmannii* (minor climax)	*C. rossii*	Steele et al. 1983
Pinus albicaulis-Abies lasiocarpa H.T.	Mountains of northern Idaho	Cool dry	Co-climax with *P. albicaulis*	*P. albicaulis* *P. engelmannii*	*V. scoparium* *A. latifolia* *Hieracium gracile*	Cooper et al. 1983[4] Pfister et al. 1977

Habitat type, community type, plant community	Location	Site	Successional status of *A. lasiocarpa*	Principal tree associates	Principal understory species	Authority[1]
			Larix lyallii series			
Larix lyallii-Abies lasiocarpa H.T.	Mountains of Montana west of Continental Divide	Cool dry	Co-climax with *L. lyallii*	*L. lyallii* *P. engelmannii* *P. contorta*	*P. empetriformis* *V. scoparium* *L. hitchcockii*	Cooper et al. 1983[4] Pfister et al. 1977
Larix lyallii / P.C.	Eastside Cascades, north-central Washington	Cool dry	Seral to *L. lyallii*	*L. lyallii* *P. engelmannii* *P. albicaulis*	*Cassiope* spp. *V. scoparium* *P. empetriformis*	Williams and Lillybridge 1983
			Chamaecyparis nootkatensis series			
Chamaecyparis nootkatensis / Rhodedendron albiflorum P.C.	Cascades, southern Washington and northern Oregon	Cool wet	Seral to *C. nootkatensis*	*C. nootkatensis* *T. mertensiana* *P. menziesii* *P. engelmannii* *A. amabilis*	*R. albiflorum* *Vaccinium ovalifolium* *V. membranaceum*	Franklin 1966
Chamaecyparis nootkatensis / Lysichitum americanum P.C.	Mountains of southern British Columbia	Cool wet	Seral to *C. nootkatensis*	*C. nootkatensis* *T. mertensiana* *P. engelmannii* *A. amabilis*	*L. americanum* *Coptis asplenifolia* *O. horridum*	Brooke et al. 1970

[1]*Alexander, Billy G., Jr., E. Lee Fitzhugh, Frank Ronco, Jr., and John A. Ludwig. 1984b. A classification of forest habitat types of the Cibola National Forest, New Mexico. Draft of manuscript in preparation.*

[2]*Youngblood, Andrew P. 1984. Coniferous forest habitats of central and southern Utah. Draft of manuscript in preparation.*

[3]*Steen, Ordell, and Ralph Dix. 1974. A preliminary classification of Colorado subalpine forests. Unpublished report, 10 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.*

[4]*Cooper, Steven, Kenneth Nieman, and Robert Steele. 1983. Forest habitat types of northern Idaho. Unpublished Report, 210 p. Intermountain Forest and Range Experiment Station, Ogden, Utah, and Northern Rocky Mountain Region, Missoula, Mont.*

[5]*Hess, Karl, and Clinton H. Wasser. 1982. Grassland, shrubland and forestland habitat types on the White River and Arapaho National Forests. Final Report, 335 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.*

[6]*DeVelice, Robert L., John A. Ludwig, William H. Moir, and Frank Ronco, Jr. 1984. A classification of forest habitats in northern New Mexico and southern Colorado. Draft of manuscript in preparation.*

[7]*Fitzhugh, E. Lee, William H. Moir, John A. Ludwig, and Frank Ronco, Jr. 1984. Forest habitat types on the Apache, Gila and part of Cibola National Forests. Draft of manuscript in preparation.*

[8]*Komarkova, Vera. 1984. Habitat types on selected parts of the Gunnison and Uncompahgre National Forests. Preliminary Report, 254 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.*

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Rocky Mountains

Southwest

Great Plains

U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

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